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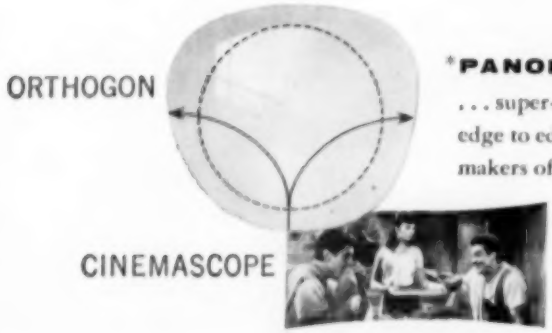

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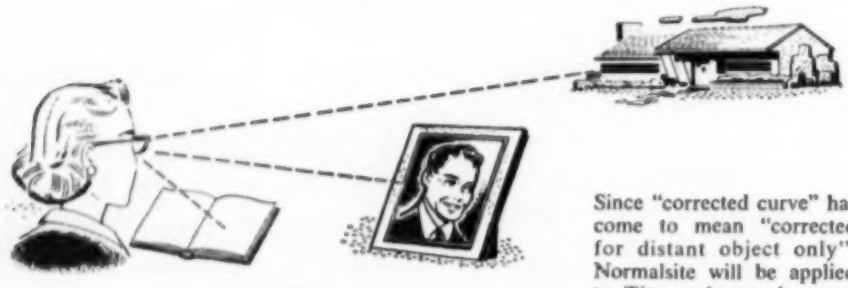

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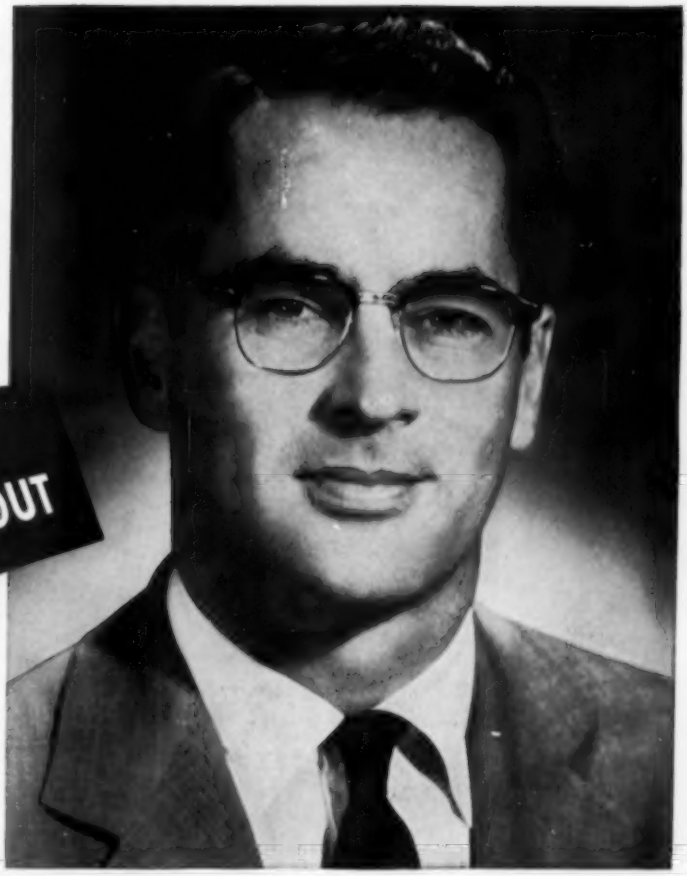

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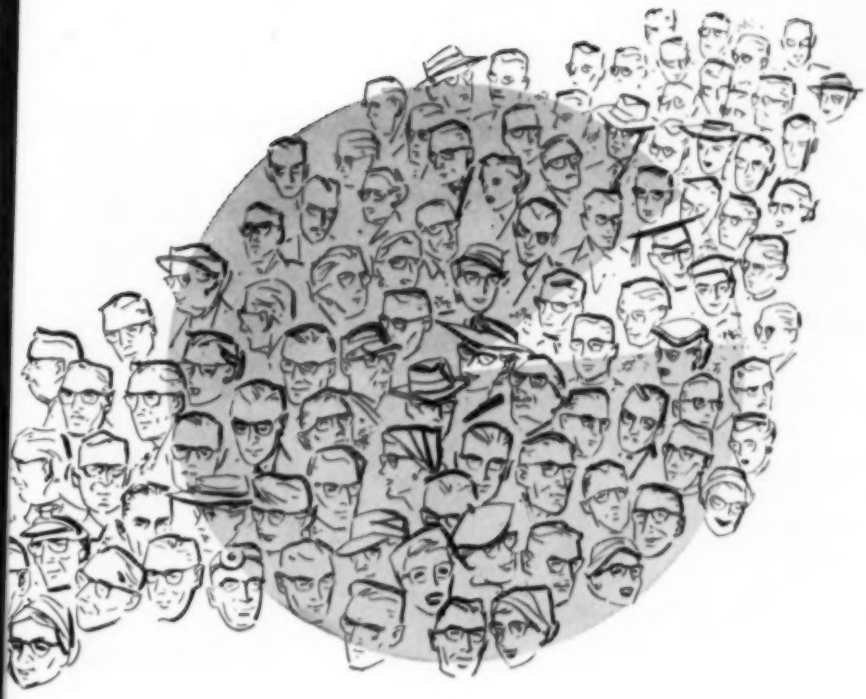

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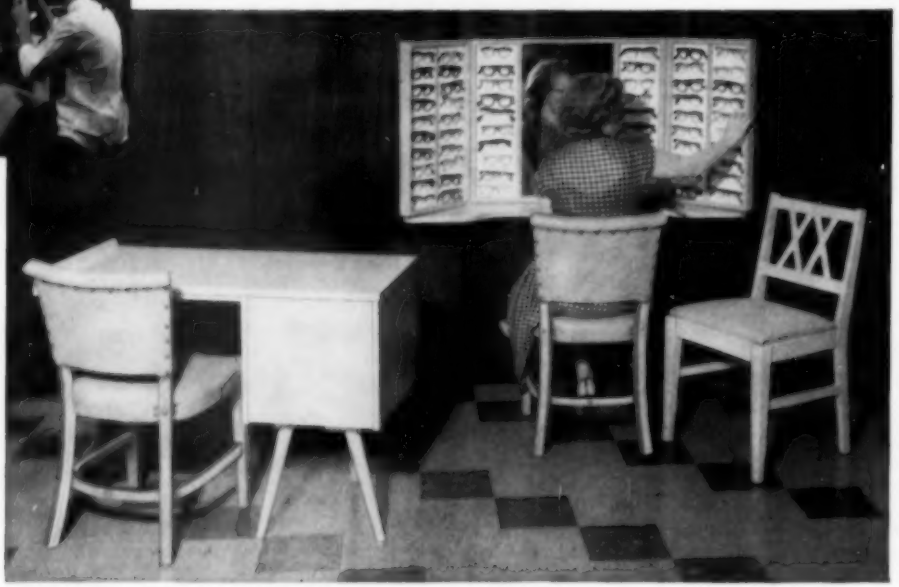

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AN EVALUATION OF SCLERAL TONOMETRY*
ITS RELIABILITY, VALIDITY AND CLINICAL APPLICABILITY

Monroe J. Hirsch†
Ojai, California

Whether a test is good or not is expressed in terms of its reliability and validity. The former term refers to the repeatability of the test and indicates whether successive trials will yield similar results. Validity expresses how closely the test measures that variable or function which it purports to measure. All tests, psychological, physiological, or physical may be described in terms of these two values.

Although scleral tonometry is not a new technique for estimating the intraocular pressure and although it recently has been discussed in the literature,[1,2] its reliability and validity do not seem to have been established. One purpose of the present experiment was to attempt to arrive at these values.

In addition to reliability and validity, a third criterion may be applied to clinical tests. Tests yield certain information, and of the large number of ocular tests which one might use, only a relative few are ever performed upon a patient. Tests may be time-consuming, may require costly equipment, may cause discomfort or danger to the patient, or many require a trained observer. The information may not be sufficiently important, or it may be more easily obtained by another test or tests. The third criterion, clinical applicability, is, then, a determination of whether the information yielded by the test has sufficient value to compensate for the negative factors which are entailed in the administration of the test.‡ A second purpose of the present experiment was to determine the clinical applicability of scleral tonometry.

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‡Visual acuity measurements are clinically good tests since they give the examiner a valuable datum while taking little time and equipment and not discomforting nor endangering the patient. The x-ray measurement of the axial diameters of the globe, however, is still not clinically applicable. Although this test is highly reliable and valid, the information which it offers to the clinician is not sufficiently important to warrant the time that the test would require in the clinical situation, the cost of the equipment, and the possible danger to the patient of the procedure.

PROCEDURE

A Wolfe Tonometer which recently had been recalibrated for use as a scleral tonometer was used in all of the experiments. The instrument has been described adequately in the literature, and the procedure followed was that suggested by the manufacturer, with those modifications that became necessary as the experiment proceeded. The subjects were patients in our optometric practice. During the period of the experiment, scleral tonometry was performed on every patient over the age of thirty for the first and second series, and over the age of forty for the third series. The subjects, then, are consecutive patients in an optometric practice. The three experiments were performed chronologically, and the findings of one led to changes in the later ones. The first experiment was an exploratory study.

EXPERIMENT I.

There were forty subjects in this study, and the data include, in addition to the intraocular tension as measured by the tonometer, the age, sex, and refractive state (equivalent sphere) of the subject. The tension was taken three or four times and these findings averaged. The number of readings depended upon the spread between readings. Thus, if three quite similar readings were obtained, this was considered sufficient. On the other hand, if one of the three differed widely from the other two, further readings were taken. This technique has limitations, but since the experimenter had no preconceived ideas or bias, he felt safe in resorting to a less rigid procedure than might be used in a laboratory experiment. The fact that the subjects were office patients limited the amount of "experimentation" that could be done.

If emmetropia be defined as 0.50 D. of refractive error or less, then the sample of eighty eyes contained 37 emmetropic eyes, 31 hypermetropic eyes, and 12 myopic eyes. Table I gives the essential descriptions of these groups.

TABLE I

Category	Number of Eyes	Mean Tension (mm. Hg.)	Standard Error of Mean	Standard Deviation
Myopic	12	19.5	1.19	3.77
Emmetropic	37	22.8	0.74	5.22
Hypermetropic	31	21.5	0.38	3.45
Total Sample	80	21.9	0.50	4.49

Comparing the three pairs of means by the t test yielded the following data:

TABLE II

Variables	Mean Difference (mm. Hg.)	t	P
Myopia-Emmetropia	3.3	2.4	0.02
Myopia-Hypermetropia	2.0	1.6	0.10
Hypermetropia-Emmetropia	1.3	1.2	0.30

It is seen in Table II that the only difference approaching statistical significance is that between myopes and emmetropes, the tonometer reading for myopes being somewhat lower. There are many references in the literature (Case,[3] Lagrange,[4] and Lacroix[5]) to the fact that high myopes (9.00 D. or more) frequently have low intraocular tensions. However, 11 of the myopic eyes in the present sample were between 0.50 D. and 2.50 D., while the other was a 4.00 D. myopic eye, and myopes of such magnitude are not usually assumed to have lower intraocular pressures. The interpretation of the significant relationship found here will have to await similar studies on a larger sample. Important to the present study, however, is the fact that for moderate refractive differences, the average scleral tonometer readings do not differ by more than 3 mm., and refractive state need not be considered in subsequent experiments. In the establishing of normal values, if refraction be considered at all, the value for myopes may on the basis of this meager sample be tentatively assumed to be 2 or 3 mm. lower than the average for emmetropes and hypermetropes.

The average value for the sample of 80 eyes was approximately 22 mm. and the standard deviation was 4.5 mm. If, as is often done clinically, two standard deviations on either side of the mean are taken as the normal limits, it is seen that the middle 95 per cent of the eyes have pressures between 13 and 31 mm. In a survey of corneal tonometry values, Duke-Elder[6] cites particularly the findings of Cridland who averaged the figures of eight other authors and found an average of 19.1 with a range of 12.3 to 26.1, and those of Müller who found the extreme normal limits to be 12 and 35 mm. The close agreement between the values in the present experiment and those customarily found by corneal tonometry tends to establish the validity of the test. Not only are the average values similar, but the range seems to be almost identical. While this similarity does not prove that scleral tonometry is measuring the same variable as corneal tonometry, it certainly is compatible with such an hypothesis. However, as will be shown presently, the distribution curve for scleral tensions is skewed, and this does not seem to be true for corneal tonometry.

The mean for the 19 men in the present sample was 22.0 mm. while that for the 21 women was 21.8 mm. This difference is not significant, and the scores for men and women may be grouped in later studies with no allowance for sex differences being made in establishing norms.

There were twenty patients between the ages of 30 and 49, and a like number between the ages of 50 and 69. The mean for the

younger group was 22.1 mm. Hg. and for the older group, 21.7 mm. This difference, too, is not significant, and age, therefore, seems not to be a factor. It should be pointed out that this group was somewhat homogeneous with respect to age, and, therefore, the above findings may be misleading. Intraocular pressure, like blood pressure, probably varies little throughout life for most people, but rises markedly for a few anomalous patients. Our findings neither prove nor refute such an hypothesis; if, however, it is true, then this sample must contain few, if any, anomalous patients, a condition we believe to be true.

The mean tension for the 40 right eyes was 22.1 mm. and that for the 40 left eyes was 21.7 mm. This difference is not significant, indicating that in future calculations the data for the two eyes may be combined.* The coefficient of correlation between the value for the right eye and that for the left eye was +0.89, a value remarkably high, especially when it is compared with the reliability coefficients. This finding is encouraging, since it is probable that tension is the same or nearly so in the two eyes. The coefficient of correlation between the two eyes is neither a measure of reliability nor validity, but its high value is encouraging, especially in so far as validity is concerned.

On the basis of the first experiment, certain general conclusions may be reached. The values seem to be little affected by age (within the range of 30 to 70), sex, or laterality. The values for myopes seem to be two or three millimeters below the average. The average value is 22 mm. and the standard deviation 4.5, values close to those obtained by corneal tonometry.

EXPERIMENT II.

At this point it was decided to do a standard test of reliability. The procedure was to take one reading only on the right eye, and then one on the left. This constituted the test. After a minute or two, the procedure was repeated, constituting the retest. The subjects were the next thirteen consecutive patients between the ages of 30 and 70. The experiment was cut off after the thirteenth patient because of a number of obvious defects which will be discussed.

The basic data for this experiment, then, are single readings for thirteen patients, consisting of $Test_{right}$, $Test_{left}$, $Retest_{right}$, and $Retest_{left}$. The mean values were as follows:

$Test_{right}$	22.0
$Retest_{right}$	23.9

*It is interesting to note that, as the experiment progressed, we had the feeling that we were finding much lower readings for the left eye. This apparently is not the case and serves to illustrate how wrong clinical impressions can sometimes be.

$Test_{left}$	22.2
$Retest_{left}$	21.6

For the small numbers involved no one of these averages differed significantly from any other. The Test-Retest correlations are, of course, the reliability coefficients. These were +0.44 for the right eye and +0.72 for the left. The low value for the right eye was disappointing, but was not unexpected. During the course of the experiment we had the impression that occasional "wild" values were obtained particularly on the first measure taken, the $Test_{right}$. It seemed that if a single value were to be taken, the second value would be more representative than the first. Rather than proceed with the experiment, it was ended and a new series begun to attempt to establish this hypothesis, namely, that the first reading was the least representative.

EXPERIMENT III.

The procedure was the same as in Experiment II except that three sets of readings were taken and recorded. Thus, a single reading of tension was taken and recorded for the right eye and then the left. After a minute or two, this was repeated a second time and the two values recorded. Then, after another minute or so, the tension for the right and left eye was measured for a third time. The subjects were the next 23 consecutive patients over the age of 40.

The mean values for the three trials (average of 46 eyes for each) along with their standard deviations are presented in Table III.

TABLE III

Trial	Mean	Standard Deviation
First	20.0	5.00
Second	20.3	3.88
Third	19.9	3.18

A number of things are apparent from this Table. The average values are slightly lower than for the initial experiment, a difference not significant, but which we feel is real and due to greater experience in the use of the tonometer. These values are almost identical with those previously cited for corneal tonometry. The standard deviation came steadily down and the difference between that for the first and third trial is significant by the F test to the one per cent level. This bears out our suspicion that there were wild or unrepresentative values in the first trial.

The test-retest coefficients of correlation were as follows:

Between first and second tests	+0.56
Between first and third tests	+0.49
Between second and third tests	+0.77

That the two coefficients which include the first test are markedly lower than that which does not amply proves our hypothesis. It may, then, be stated that the reliability coefficient for this instrument is about +0.77, provided that the first reading for each eye is discarded.

It may be argued that the test-retest correlation should be obtained with the retest performed on a different day from the test, and perhaps this datum is of value. However, we are satisfied on the basis of the above tests that after the operator gains experience scleral tonometer readings are reasonably repeatable, provided that the first reading is discarded. In comparing the three means in Table III, it will be noted that the tension does not vary appreciably upon repeated testing. Duke-Elder[7] notes that in corneal tonometry "more than three readings should not be taken, as repeated applications of the instrument . . . tend to lower the tension." Seemingly, the three readings in the present experiment were within the limit of safety, and no systematic variation was observed. It is, therefore, suggested that if an examiner will take three readings, discard the first and average the values of the second and third, he will obtain as reliable a measure as it is possible to get.

Upon the completion of Experiment III, the data for the three groups were combined to obtain a frequency distribution. There were 40 patients from Experiment I, 13 from Experiment II, and 23 from Experiment III, or a total of 76 patients (152 eyes). The values in Experiment I were average values. Those from Experiment II were averaged (test and retest), while those from Experiment III were the average values for the three trials.

The frequency distribution is presented as Table IV and as Figure 1. In the figure, the points are observed frequencies while the curve is fit by the method of "averaging by threes."

The distribution curve seems to be bimodal, or composed of two distributions which overlap in the region of 22 to 26 mm. If the major distribution curve were extended, it would intersect the X-axis at about 26 mm. This is of some interest in view of the statement by Weinstein and Foldes[8] that "if the tonometer (corneal) reading is above 26 mm. Hg., we are confronted with glaucoma." It would appear that the scleral tonometer readings could be used to separate glaucoma from non-glaucoma patients very adequately, with the line of demarcation occurring, as in corneal tonometry, at 26 mm. However, it is noted in Table IV that 21 of the 152 eyes or 14 per cent of the total number had tensions in excess of 26 mm., while 11 eyes or another 7 per cent had pressures of exactly 26 mm. Duke-Elder[7] summarizes the existing data on incidence of glaucoma with the statement that it "represents from 1 to 2 per cent of all ophthalmic cases." Even if,

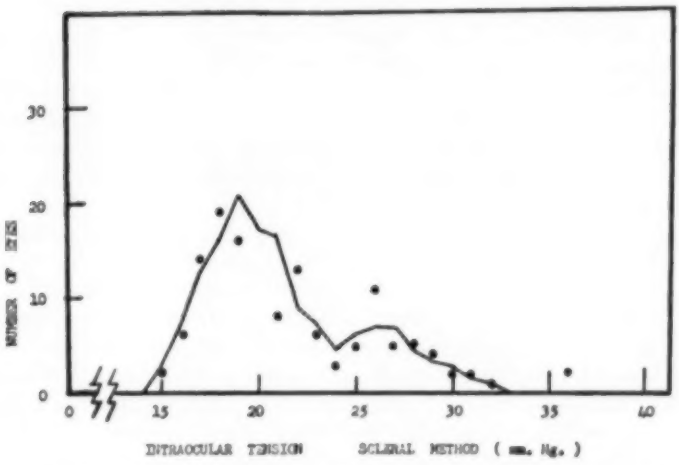

Fig. 1. Frequency distribution of intraocular tension by scleral tonometry for 152 eyes. Solid circles are observed frequencies; the curve is drawn to points arrived at by "averaging by threes."

TABLE IV

Scleral Tonometer Reading	Number of Eyes
15	2
16	6
17	14
18	19
19	16
20	28
21	8
22	13
23	6
24	3
25	5
26	11
27	5
28	5
29	4
30	2
31	2
32	1
33	0
34	0
35	0
36	2
	152

as Weinstein and Foldes claim, the incidence has increased in recent years, the increase is only of the order of magnitude of 1 per cent.

From the distribution curve we must conclude the following: (1) In the clinical interpretation of scleral tonometry findings, any

value above 25 mm. must be regarded with suspicion, but in all probability glaucoma is not present in the majority of patients with such pressures. A reading above 30 mm., on the other hand, may be regarded with extreme suspicion. The large number of patients with tensions between 25 and 30 mm. may be caused by the presence of a group whose tension is normal but whose scleral tissue is particularly rigid. (2) If, as Weinstein and Foldes maintain, glaucoma is present in patients whose pressure exceeds 26 mm. Hg., then the validity of scleral tonometry must be questioned. Were it to be used as a screening test for glaucoma with the point of demarcation at 26 mm., then it would have a high "over-referral error." On the other hand, if the higher value of 30 mm. is used as the point of demarcation, then the test results are compatible with validity, but the reason for the bimodality remains obscure. It may, as has been suggested, be due to the existence of scleral rigidity in about 15 to 20 per cent of the population, or it may be due to some other uninvestigated phenomenon or artifact.

DISCUSSION

The three criteria for the evaluation of the scleral tonometry test may now be considered.

(a) *Reliability.* The present experiments have served to demonstrate the reliability of the scleral tonometry technique, especially if the first readings are disregarded. The reliability coefficient of +0.77 between second and third readings is good for a test of this sort. Furthermore, if two or three readings are taken and averaged, it would tend to further increase the magnitude of the reliability coefficient.

Duke-Elder[7] cites Müller (1932) as having set the limits of ±5 to 7 mm. as the instrumental error of corneal tonometry. For scleral tonometry the reliability coefficient of +0.77 yields a coefficient of alienation of 0.55; for the standard deviation of the third trial results of 3.18 mm., the standard error of the regression coefficient is 1.76. Thus, if 95 per cent confidence is desired, the accuracy of predicting the pressure on the third trial on the basis of the second will be ±3.52 mm., while the value for 99 per cent confidence (three standard errors) will be ±5.28. These values compare very favorably with those for corneal tonometry as cited by Müller. They indicate that in the clinical situation, any change of pressure in excess of about 4 mm. may be regarded as being due to factors other than chance. The scleral tonometer, therefore, may be presumed to be as accurate an instrument for use with provocative tests or for diurnal variations as is the corneal tonometer. Such use of scleral tonometry remains to be further explored, but the data of the present experiment indicate that this field may prove most fruitful.

(b) *Clinical Applicability.* The problem of clinical applicability of a test does not lend itself easily to solution by quantitative data, but, rather, must be evaluated upon a less rigid basis. Scleral tonometry is not a time-consuming test, requiring only a minute or two. The cost of the instrument is not great, and the discomfort to the patient is not a serious problem, although a few individuals complain of the sensation. We found it best not to tell the patient too much about what is to be done, but merely to inform him that he may experience a slight sensation and not to attempt to look away from the fixation object.

The sole clinical objection to the test lies in the possible danger to the patient. In using the tonometer on approximately 200 patients, we have had two unhappy incidents. One patient who did not follow the instructions to look at the fixation object, moved the eye suddenly as the tonometer foot was on the sclera. This resulted in a subconjunctival hemorrhage, a condition not serious but decidedly alarming to the patient and unpleasant for the practitioner. This incident serves to emphasize the need for instructing the patient to continue to regard the fixation object. A second patient had a subconjunctival hemorrhage five days after scleral tonometry had been performed. Clearly, this was coincidental and not associated with the test. However, the patient, recalling that something had touched the eye, suggested that this test had been the cause. It is our belief, after using the procedure, that there are no real dangers to the patient if the instrument is used carefully. On the other hand, anyone using the instrument regularly must expect an occasional incident like those just described. These can be tolerated if the test is a valid one and is aiding in the detection of glaucoma. Thus, the advantages of the test on a clinical basis must be considered in the light of the third criterion, the validity.

(c) *Validity.* If a valid test already exists, then the results of a new test may be correlated with those of the known valid test in order to determine its validity. However, in the absence of a valid test, the establishment of the validity of a new procedure is extremely difficult. In the present study, scleral tonometry may, for purposes of determining its validity, be considered in two different regards: (1) The validity of scleral tonometry as a measure of intraocular tension. To determine this, it would be necessary to correlate scleral tonometry readings with those of a known valid test for intraocular pressure. (2) The validity of scleral tonometry as a test for glaucoma. To determine this, it would be necessary to compare the results of scleral tonometry upon a group of subjects with glaucomatous eyes and upon another group with glaucoma-free eyes.

With regard to the first possibility, to set up such an experiment would necessitate (assuming that corneal tonometry is a valid measure of intraocular pressure), a large sample of patients with at least suspected glaucoma. Clinical tests could then be run on these patients using both corneal and scleral tonometers. A weakness of such an approach lies in question of the validity of corneal tonometry as an absolute measure of intraocular pressure. Duke-Elder[7] ably sums up the situation by discussing the numerous sources of error and concluding that "when these are taken into consideration collectively, the impression may be gained that the value of any tonometer is very limited indeed. In the strictly scientific sense this is undoubtedly so, but as an instrument of clinical utility the case is very different: no clinical instrument is scientifically accurate, and when compared with many, the standard of accuracy attained by a good tonometer is high. When this is remembered in the interpretation of its readings, its value is very considerable. Especially is this so when it is used on a comparative basis, for example, *in comparing the two eyes of the same individual at the same time* it can detect very slight differences of pressure, or *in following the variations of the tension in the same eye at different times* it provides a series of observations which, although of little value as absolute readings, especially when translated into millimeters of mercury, provides a comparison on a numerical basis, free from subjective interpretations, which cannot be obtained by any other method."

Since absolute values of corneal tonometry must be considered with great care, the correlation between such findings and absolute scleral tonometer values seems to be not too fruitful an avenue for research. On the other hand, since the greatest value of corneal tonometry lies in its repeated use on the same patient, a similar approach in scleral tonometry would seem to be most promising, especially since this technique has been shown to be reliable. The results of the present experiment are sufficiently encouraging to warrant further experiments in which provocative tests and diurnal tests are made with the use of the scleral tonometer and its validity as a test of glaucoma considered.

The second possibility for validating the technique, by determining how well it aided in picking out patients with glaucoma, is also not free of difficulty. Glaucoma is not a simple disorder and the classification of patients into categories of glaucomatous and nonglaucomatous is difficult by any test or series of tests. Thus, a statement of the validity of scleral tonometry can never be any more certain than one of the validity of the classification of glaucoma.

The above considerations undoubtedly account for the fact that the

validity of scleral tonometry has never been clearly established. It is not easy to establish validity when there is no other valid measure which may serve for comparison. It has, however, been shown in the present experiments that scleral tonometry furnishes an estimate of the intraocular pressure. The results are of the same order of magnitude as those obtained by corneal tonometry in so far as mean and dispersion are concerned. The values of scleral tonometry compare favorably with those of corneal tonometry in such respects as effect of age, sex, laterality, and refraction. If validity has not been demonstrated in the present experiments, at least an hypothesis of validity is compatible with the results.

Perhaps the greatest argument against the validity of scleral tonometry is to be found in the distribution curve. This, as has already been stated, is bimodal, a condition not descriptive of intraocular tension. It must be concluded that scleral tonometry is affected by some factor other than and in addition to the intraocular pressure. The hypothesis has been advanced that this factor is the degree of rigidity of the sclera. If this is the case, then between 15 and 20 per cent of the population has scleral rigidity of such degree as to lead to unduly high scleral tonometer readings.

It is clear that the scleral tonometer cannot be used in the same manner that the corneal tonometer is used, i.e., with a single point of demarcation (26 mm. Hg.) differentiating abnormal from normal pressure. In scleral tonometry, patients must be divided into three categories, namely: (1) those with normal pressure (readings below 25 mm. Hg.); (b) those with abnormally high pressure (readings above 30 or 32 mm. Hg.); and (c) those who have either high intraocular pressure or undue scleral rigidity (readings between 25 mm. Hg. and 30 mm. Hg.). Unfortunately, a good segment of the population (15 to 20 per cent) fall in this third group. Furthermore, it is often in this group that a differential diagnosis is so important.

CONCLUSIONS AND SUMMARY

(1) If the first reading obtained is discarded and the next two readings are averaged, the scleral tonometer is a reliable clinical test.

(2) The average value seems to be close to 20 mm. Hg. with the normal range being between 15 and 25 mm. Hg.

(3) Values of between 25 and 30 mm. Hg. may be regarded as suggestive of an elevated pressure, but in all probability do not indicate the presence of glaucoma. About 15 to 20 per cent of the population has readings in this group. The hypothesis has been advanced that

most patients in this group have scleral structure as the basis of the high reading, rather than high intraocular pressure.

(4) Values above 30 or 32 mm. Hg. may be regarded with extreme suspicion and may indicate abnormally high pressure.

(5) The values obtained by scleral tonometry seem to be little affected by age, sex, or laterality.

(6) The values for myopes of moderate degree may be approximately 2 or 3 mm. Hg. below the average, an interesting phenomenon, particularly in view of the hypothesis of scleral rigidity hitherto advanced.

(7) Variations of pressure for the same individual in excess of between 3 and 5 mm. Hg. may be assumed not to be due to chance.

(8) The technique of scleral tonometry is simple, rapid, and not costly. There is neither marked discomfort to the patient nor any serious danger. The possibility of subconjunctival hemorrhage has been mentioned.

(9) The values obtained by the scleral tonometer have been shown to be comparable to those of the corneal tonometer in mean and standard deviation, but not in skewness.

(10) Because of the nature of the disease and the difficulty in obtaining a clear-cut diagnosis of glaucoma, it is almost impossible to arrive at the validity of the technique. No evidence to suggest a lack of validity has been encountered, but a lack of sensitivity in the range from 25 to 30 mm. Hg. has been noted.

(11) The chief value of the instrument probably lies in its use on the same patient at different times of the day and in its interpretation in the light of the findings on visual fields and other tests.

(12) The inherent weakness of tonometry in the diagnosis of glaucoma seems to hold equally for scleral tonometry and corneal tonometry. The instrument must be used as a clinical tool and not as an absolute screening device for glaucoma.*

(13) Future research should be devoted to studying the scleral tonometry technique as a measure of diurnal variations in pressure and in conjunction with provocative tests.

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*This conclusion has been expressed earlier by at least one proponent of scleral tonometry, Ralph Wick, at the Pathology Section of the Annual Meeting of the American Academy of Optometry, Chicago, Ill., December, 1953.

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ABSTRACT

CORRELATING VISUAL AND OCCUPATIONAL EFFICIENCY. Brian J. Cox, O.D., F.A.A.O. Optometric Weekly. (1) September 16; (2) September 30; (3) October 14; (4) November 4, 1954.

As a result of reviewing available literature (51 references are given) concerning visual efficiency and functional efficiency on the job, the author concludes "that there is no one stereotype or even a small group of stereotypes of desirable visual function. It seems that the demands of each task classification are distinctive. Therefore, the aim cannot be to bring every individual examined and treated up to the same set standard of performance in all aspects of visual function. Rather, it must be a coordinated procedure of analysis of the job or task, analysis of the visual function and analysis of the person generally."

The literature cited in this paper provides an excellent view of what has been done to correlate occupational and visual efficiency. The value of good vision in occupational efficiency is sensibly appraised—after considering various studies which indicate that it is often difficult to demonstrate a real gain for the individual. From the information he has collated, the author lists certain tests, investigations, and deductions which may be made in the interest of visual and functional efficiency.

ROBERT E. BANNON, O.D.

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A SIGN OF MANIFEST HETEROZYGOSITY IN CARRIERS OF COLOR DEFICIENCY*

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Congenital red-green deficiency is transmitted by the sex chromosomes which are designated by XY in the male and by XX in the female. With the male only the one X chromosome has to be affected in order to cause color deficiency but in the female both X chromosomes must be affected before color defect is produced. Where only one of the X chromosomes is affected in the female, she will be a carrier. A woman may be color defective when her father is color defective and her mother either a carrier or a color defective. The preceding are the general rules of transmission of congenital red-green deficiency.

The subject is, however, far more complicated since we distinguish four types of red-green deficiency: protanomaly (PA), protanopia (P), deuteranomaly (DA), deuteranopia (D). Protanomals and protanopes are called protoforms by a joint name, deuteranomals and deuteranopes, deuteroforms. It is a well established fact that the genes for protanomaly and for protanopia together with a normal gene constitute a multiple allele series. Likewise a normal gene with the genes for deuteranomaly and for deuteranopia constitute another series of multiple alleles. The genes of these two allele series are not alleles to each other: evidently, they have a different location in the X chromosome. Both series reveal a dominance sequence:

$$N > PA > P \text{ and } N > DA > D$$

e.g., a woman with one gene for normal and one for protanomaly is phenotypically normal, a woman with a gene for protanomaly and a gene for protanopia is protanomalous. A woman with two genes for protanopia is a protanope.

The following table shows the combinations of all female types, by assuming for simplification, that the normal gene is common for both allele series.

There are four types of heterozygotes with one normal and one affected X chromosome. They are phenotypically normal. Females

*Read before the annual meeting of the American Academy of Optometry, Toronto, Ontario, Canada, December 12, 1954. For publication in the August, 1955, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

†M.D. Member of faculty.

		Genotype X	Genotype X	Phenotype
		PA	N	N
		P	N	N
	Heterozygotes	N	DA	N
		N	D	N
	non-allelic	PA	DA	N
Homozygotes	compounds	PA	D	N
for		P	DA	N
color		P	D	N
deficiency		PA	PA	PA
	allelic	P	PA	PA
	compounds	P	P	P
		DA	DA	DA
		D	DA	DA
		D	D	D

with both chromosomes affected are so-called compounds. They are non-allelic compounds if the two genes originate from different allele series (four types). They are phenotypically normal since evidently the two non-allelic genes neutralize each other. Those with two defective genes originating from the same allele series are allelic compounds and are phenotypically color defective (six types).

There has been some evidence, however, that the normality gene of heterozygotes is imperfectly dominant and that the genes in non-allelic compounds do not perfectly neutralize each other. There are reports about slightly widened matching ranges and shifting the average setting on the Nagel anomaloscope, but these results do not permit distinguishing between different types of carriers or even carriers from non-carriers.

The following results were based on the investigation of 35 carriers: 7 for protanomaly, 6 for protanopia, 17 for deuteranomaly and 5 for deuteranopia. They were most probably normal-color defective heterozygotes, their type being defined by their color deficient sons. As far as their families were investigated there was no evidence for a compound. All 35 carriers passed color vision chart tests. On the anomaloscope some of them showed enlargement of their matching range, the average being normal. Most carriers of protoforms have their average settings between the normal mean and the normal limit toward protanomaly and the carriers of deuteroforms have their average settings between the normal mean and the normal limit toward deuteranomaly. Since the settings are within the normal range, it is impossible to recognize a carrier by her anomaloscope settings.

One carrier for protanomaly showed an extremely large scatter on the anomaloscope by matching even pure red and pure green with yellow. The amounts of the comparison yellow which were required to match

were intermediate between those of normals and those of protanopes. This result suggested measuring her luminosity curve which showed an intermediate course between that of normals and that of protanopes. The luminosity curves of nine other carriers of protoforms showed a similar deviation with slight individual differences which, however, did not allow a discrimination of a carrier of protanomaly from that of protanopia. The luminosity curves of nine carriers of deuteroforms coincided with that of a normal person. Figure 1 shows luminosity

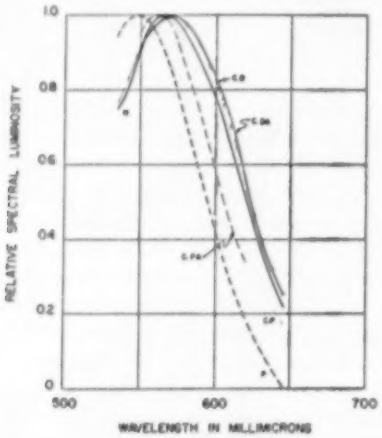

Fig. 1. Spectral luminosity curves of one normal, one protanope, two protoform carriers and two deuteroform carriers. N-normal, P-protanope, C.PA-carrier of protanomaly, C.P-carrier of protanopia, C.DA-carrier of deuteranomaly, C.D-carrier of deuteranopia.

curves of two protoform carriers and two deuteroform carriers in comparison with a normal person and with a protanope.

The data were published some years ago.[1] Since then, the first paper discussing and confirming these results was a monograph of Walls and Mathews.[2] The authors used a three-light test, where a red and a blue light were adjusted in brightness to a green light which gave sufficient information about the luminosity functions of the subject. With this method they found that a mother and two sisters of protanopes had what they called "Schmidt's sign"; namely, these intermediate luminosity functions. Whereas, everyone of the protoform heterozygotes mentioned above had this sign, Walls and Mathews

[1] I. Schmidt. Klin. Mbl. f. Augenhk. 92. 456. 1934.
[2] G. L. Walls and R. W. Mathews. New Means of Studying Color Blindness and Normal Foveal Color Vision. Univ. Calif. Publ. in Psychology, Vol. 7, No. 1, 1952.

found that it is not always present. The mother of one protanope did not show it. (It would be interesting to follow up whether she was a non-allelic compound so that both genes could have neutralized each other.) In a recent paper Walls[3] published a pedigree with two cases having this sign and one heterozygous woman having a complete manifestation of protanopia.

According to an explanation by Walls the protoform carrier accepts the normal Rayleigh equation on the anomaloscope (red + green = yellow) because the same thing is lacking from both sides of the equation. She is lacking a share of the brightness which each half of the stimulus equation would afford to the non-carrier. At the same time the contribution of the carrier's receptors to chromaticness is normal.

Wall's figurative representation of his branched pathway hypothesis of color vision illustrates this relation especially well (Figure 2). He

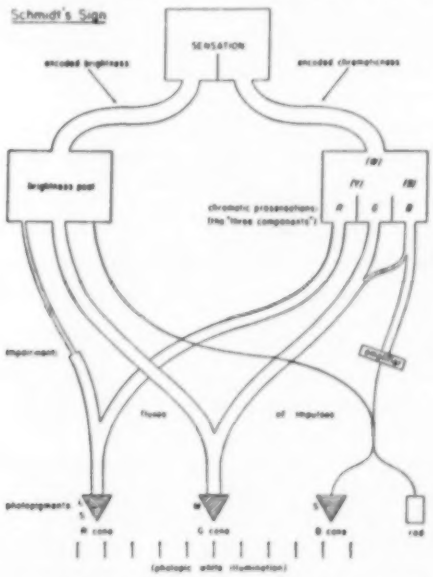

Fig. 2. Branched pathway scheme after G. L. Walls.

distinguishes three types of cones which make a contribution to chromaticness: redness, greenness and blueness receptors. They simultaneously contribute to brightness in a different ratio. The receptors send nerve impulses along a bifurcated path, the one branch ending in a brightness

[3] G. L. Walls, Amer. J. Ophth. Vol. 39, No. 2, Part II, 8, (1955).

pool, the other in a chromaticness blending station. According to Walls, in protanopes the redness receptors are lacking, in protanomals they are reduced in numbers and photochemically abnormal, but in protoform heterozygotes the redness receptors are normal photochemically and in numbers. The defect is rather at the pathway level. The brightness branch of the red-cone pathway is somehow impaired so that it carries a reduced flux of impulses. Nothing else is wrong but this is enough to dim for such a woman any yellow light, and more so orange and particularly red light, while leaving her color vision undisturbed.

The shift of the luminosity curve of protoform-heterozygotes implies that the gene for color deficiency is incompletely recessive. The result is a contribution to our theoretical concept about color vision since it suggests that brightness and chromaticness must be mediated independently in the visual system. The detection of carriers is not only of theoretical but also of practical interest because carriers should be excluded from serving as experimental subjects in any research work on normal color vision.

ERRATA

THE WORD "OPTICIANRY" DEFINED

It has been called to our attention that we have used the term *Opticianry* rather loosely and have been requested to use more care in our future use of this term.

The word "Opticianry" is defined by Dr. Charles Sheard* as "the art and science of optics as applied to the compounding, filling and adapting of ophthalmic prescriptions, products and accessories." Using this definition, the word *opticianry* relates to the entire field of lens and frame making, laboratory processes and techniques, and the dispensing of ophthalmic products.

At times we have been guilty of using the term only as it relates to dispensing opticians. In the future we will qualify the term so that the word *opticianry* does not become synomomous with *dispensing optician*. We regret our prior use of this term.

CAREL C. KOCH

*Purposes and Functions of the American Board of Opticianry.

ACCURATE CLINICAL MEANS OF MEASURING INTERVISUAL AXIS DISTANCE*

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Increasing emphasis is being placed on the proper positioning of the optical centers of ophthalmic lenses (trial case, refractor, or spectacle) with relation to the visual axes. Recognition is not generally given to the inaccuracies inherent in Viktorin's method, commonly used to measure the so-called interpupillary distance (P.D.). Furthermore, this method of P.D. measurement, even when performed accurately, does not determine the location of the visual axis upon which the optical center of the lens should be placed. Ideally, the distance between optical centers of lenses (termed O.C.D.) should correspond to the intervisual axis distance, or interocular distance,[1] abbreviated I.O.D., a term recently suggested to supplant the less accurate term interpupillary distance.

Viktorin's method of measuring P.D.'s is illustrated in Figure 1. A few of the inaccuracies of this method of measurement may be noted:

1. The observer's P.D. should be the same as the patient's.
2. Since measurement is generally made from the temporal margin of one pupil to the nasal margin of the other pupil, anisocoria will make it difficult to attain accuracy.
3. The visual axis does not necessarily pass through the cornea at its geometric center.
4. Measurements for each eye (distance from root of nose to center of pupil) cannot be made accurately.
5. There is poor repeatability by the same or by a different observer.

Many tests conducted by experienced observers have demonstrated that in groups of expert ophthalmic dispensers and refractionists using Viktorin's method of measurement there will be differences in the measurement of the same subject of as much as 3 or 4 mm. These inaccuracies were strikingly emphasized at a recent convention where one of the

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†Optician. B.S., Member, American Board of Opticianry. President, Precision-Cosmet Company.

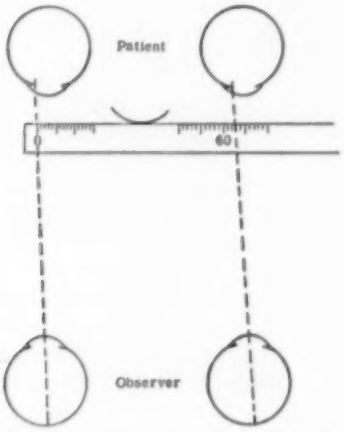

Fig. 1. Illustration of Viktorin's method of measuring P.D.'s. The patient looks at a distant object, and the observer, with his right eye closed and sighting with his left eye, sets the zero point of the ruler in line with the temporal margin of the pupil of the patient's right eye. The observer then closes his left eye and reads the P.D. distance by sighting with the right eye on the nasal margin of the pupil of the patient's left eye.

lens manufacturers had set up a hinged, wooden "nose" between two mechanically drawn "pupils." Measurements made by Viktorin's method, under ideal conditions in which there was no patient movement or other lack of cooperation, were surprisingly different from the actual P.D., as measured by laying the ruler directly on the surface on which the "pupils" were drawn when the "nose" was folded away on its hinge.

Figure 2 illustrates the necessity of determining the intervisual axis distance by some means other than Viktorin's method. Duke-Elder[2] states the problem and suggests that the distance between corneal light reflections be measured to determine accurately the "inter-axial" distance. The method suggested, while accurate, is not always the most convenient because a distant source of light, a trial frame, and lenses with etched cross lines must be used. The device shown in use in Figure 3 is a practical, easily and rapidly used instrument for measuring the intervisual axis distance. It is called the P.D.-Lite and P.D.-Meter* and is composed of two separate parts, which are used as follows:

1. The P.D.-Meter is placed on the patient's face in such a manner that the front is in the same plane as the spectacle lenses will occupy in the finished glasses.

2. Duke-Elder, W. S.: Text-Book of Ophthalmology, Vol. IV, St. Louis, C. V. Mosby Company, 1949, p. 4401.

*Manufactured by Precision-Cosmet Co., Minneapolis.

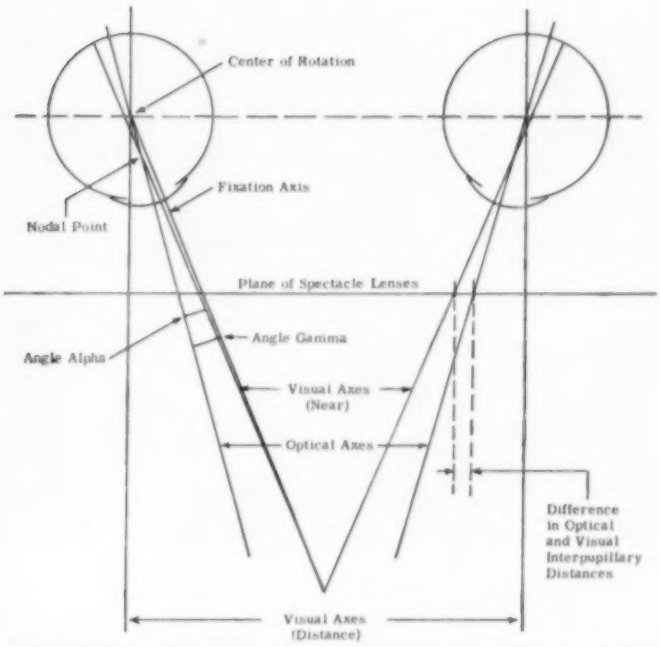

Fig. 2. Method of measuring distances between the visual axes with the P.D.-Lite and P.D.-Meter. Since the visual axis and optical axis of most eyes are not coincident, the anatomical measurement of interpupillary distance is subject to inaccuracy.

2. The P.D.-Lite's small, brilliant light source is held near the operator's sighting eye (Figure 3) at a distance from the patient's eyes equivalent to the reading distance.

3. The operator moves laterally until the white line on the extended tip in the center of the meter and the white line immediately behind it, on the meter proper, are seen as one continuous line. This assures the operator that he is on center, so that accurate individual P.D. measurements will be obtained. The sum of the distances from the center of the nose to each of the reflections on the corneas will be the near P.D.

*Individual Distance P.D. Corresponding to the Individual Near P.D.**

Near	Distance	Near	Distance	Near	Distance	Near	Distance	Near	Distance
23	24¾	25½	27½	28	30	30½	33⅜	33	35¼
23½	25¼	26	27¾	28½	30½	31	33¼	33½	36
24	25¾	26½	28½	29	31	31½	33⅝	34	36½
24½	26¾	27	29	29½	31½	33	34¼	34½	37
25	26¾	27½	29½	30	32	32½	34⅝	35	37½

*Distances are expressed in millimeters.

Fig. 3. P.D.-Lite and P.D.-Meter in use.

4. The individual distance P.D., corresponding to the individual near P.D., may be derived from the accompanying Table, which is computed for a reading distance of 16 in. (40 cm.). A center-of-rotation to plane-of-lens distance of 27 mm. was used in these computations.

The following advantages of the P.D.-Lite and P.D.-Meter for measuring intervisual axes distances are noted:

1. The method is accurate.
2. Repeatability by the same or by a different observer is excellent.
3. Individual P.D.'s may be accurately measured.
4. The observer's P.D. is not a factor, since measurements are made monocularly.

SUMMARY

A method of quickly, easily, and accurately measuring the intervisual axis distance by use of corneal light reflections is presented. The advantages of this method of measurement as compared with those of the P.D. measurement by Viktorin's method demonstrate that corneal light reflection is the method of choice when multifocal and/or lenses of rather high corrections are necessary for the patient.

450 MEDICAL ARTS BUILDING
MINNEAPOLIS 2, MINNESOTA

LIGHTING FOR THE FORGOTTEN MAN*

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A fundamental objective of lighting practice is to provide illumination upon a visual task so that it can be seen quickly, accurately and easily. During the past several decades countless researches involving many criteria have been devised and conducted to obtain fundamental data upon which the specification of light and lighting could be based. Nearly all these visual data have been presented in terms of the averages obtained by a group of observers with a given level of illumination, such as the average speed and accuracy of performance, visibility, acuity, or contrast sensitivity. The data also have been expressed in terms of the average footcandles required by the group to achieve a given level of performance, visibility, etc. The variations among the individual observers generally have been used to indicate the statistical reliability of the data.

Averaged data serve a very useful purpose by providing information regarding the relationships among the various factors involved in light, vision and seeing. However, in studying the effects of illumination upon visual performance, the responses of the individual observers would seem to be at least of equal, and perhaps of greater importance than the average response. When the data are expressed as average footcandles to obtain a given performance level, it should be obvious that only half of the individuals can achieve the specific level of performance. The question arises whether or not the differences among the group average and the individual averages are so significant as to produce a considerably lower than average visual performance by many observers when they are provided with the average footcandle level. In other words, data need to be presented in such a way that the responses of the *forgotten half* of the observers can be used to predict the levels of illumination necessary to enable them to achieve the desired performance level. Only in this way can those individuals who need them most be given the seeing conditions they require.

Unfortunately, much of the experimental visual data is obtained

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with only a few observers. Therefore, it is practically impossible to analyze the data in terms of individual performance. While data obtained with highly trained and experienced observers are invaluable for developing the relationships among fundamental factors, they do not provide a basis for determining the constants which must be used for establishing absolute values of the factors for typical seeing situations. Furthermore, threshold data usually are difficult to relate to the suprathreshold conditions involved in everyday seeing.

During the past two decades we have obtained extensive data on the relationships between visibility and illumination for a large variety of visual tasks. These studies have emphasized the usefulness of the Luckiesh-Moss Visibility Meter[1] for determining the average footcandles necessary to provide a given visibility level. A method for determining a personal correction factor has been devised[2] so that data obtained by observers who deviate from the average can be brought into line. That is, every effort was made to minimize individual differences. This has been extremely useful for enabling the comparing of data on a relative basis. It also has been shown that evaluations of visibility are related to the absolute threshold footcandle level[3] and to the brightness difference criterion.[4]

Recently in a study of brightness and comfort,[5] it was emphasized that differences among individual observers are important. A brightness that is comfortable for one person may be extremely uncomfortable for another. It seems axiomatic that the effectiveness of illumination—or task brightness—should be appraised on a similar basis in order to give all individuals an equal opportunity for seeing. Such factors as economics and ability to provide these more adequate footcandle levels are ultimately important, but are not necessary to the development of this broader concept.

In the present study, visibility measurements were made by 40 observers. Of this group, 32 were inexperienced observers. Most of them had never used the L-M visibility meter. All observers possessed so-called normal vision and wore corrective lenses if necessary. Their ages ranged from 18 to 61 years. The task was a well printed sample of 8-point type on white paper and was viewed at a distance of 16 inches. Measurements were made with 10, 20, 40, 80, and 100 footcandles. Care was taken to insure that the surroundings had minimal effect upon the observations.

Since the L-M. visibility meter and the technique of its use have been described in detail elsewhere,[1, 2] only a brief summary is given here to illustrate the significance of measurements of visibility. The instrument basically is a "reference" meter. That is, the scale has been cali-

brated in terms of the sizes of test objects that can be just barely discriminated through various portions of a circular gradient filter when viewed under standardized conditions of illumination. In essence, it is determined how dense a filter placed before the eyes must be to reduce the visual task to a threshold condition. The test objects were parallel bars, which consisted of black squares with the center one-third removed. Thus, the two bars and the space between them were identical in size. The observers were required to discriminate the width of the space which is calibrated in minutes visual angle. That portion of the gradient through which a 2-minute parallel-bar test object can just be seen by the standard observer is given a scale value of 2. Scale points of other values are similarly determined for a range of test object sizes. A visibility level, which can be assigned to any visual task, means that the task can be just barely seen through the same portion of the gradient filters as a certain size parallel-bar test object. It is simply a means for referring unlike visual tasks to a series of standard tasks and assigning a meaningful value to their visibilities. It must be emphasized that a scale value of 4, which indicates a visibility level twice that of a scale value of 2 does not necessarily mean that the former is twice as easy to see as the latter. In this respect it is similar to a thermometer which indicates degrees Fahrenheit; doubling the temperature from 20° to 40° does not mean that the latter is twice as warm. Nevertheless, both are rational and usable scales.

The experimental data are summarized in Table I, in which the observers have been arranged in order of increasing visibility as obtained with the 10-footcandle level. It can be seen that the range in visibility for a specific footcandle level is relatively large. For example, for 10 footcandles it ranges from about 2 to 5. These values indicate that to one observer the printed matter was equal in visibility to that of a 2-minute parallel-bar test object. On the other hand, another observer indicated that the visibility corresponded to a 5-minute test object. In other words, the perceptual demands of the two observers are considerably different in order for the task to be at threshold.

As the level of illumination is increased, the visibility level of the task improves. This occurs for all observers. An interesting comparison is the footcandle level with which each of several observers will obtain a given visibility level. Using a visibility level of 4.95 as a basis, observer No. 40 required 10 footcandles, while observers No. 25, 10 and 2 needed 20, 40 and 80 footcandles, respectively, in order to just barely discriminate the test object through the same portion of the gradient. Such differences are neither unusual nor unexpected and have been encountered by most researchers.

TABLE I

Visibility Levels Obtained by 40 Observers with 5 Levels of Illumination When Viewing a Sample of 8-point Type at a Distance of 16 Inches.

Observer Number	Footcandles				
	10	20	40	80	100
1	2.00	2.55	3.4	4.8	5.4
2	2.20	2.75	3.6	5.0	5.8
3	2.25	2.85	3.8	5.3	6.1
4	2.30	3.00	4.1	6.0	7.0
5	2.30	3.00	4.4	6.6	7.5
6	2.33	2.80	3.6	4.8	5.4
7	2.35	3.15	4.4	6.8	7.9
8	2.55	3.15	4.1	5.7	6.4
9	2.60	3.50	4.9	6.9	7.7
10	2.80	3.70	5.0	6.6	7.3
11	2.90	4.25	6.3	9.7	11.2
12	3.00	3.95	5.5	7.9	8.9
13	3.10	4.00	5.3	7.2	8.0
14	3.10	4.05	5.8	8.9	10.5
15	3.15	4.05	5.3	7.1	7.9
16	3.15	4.20	5.8	8.5	9.6
17	3.20	4.05	5.4	7.6	8.5
18	3.25	4.30	6.1	9.5	11.2
19	3.35	4.35	5.8	8.0	8.9
20	3.40	4.50	6.4	9.9	11.7
21	3.50	4.65	6.3	8.8	9.8
22	3.54	4.80	6.8	10.0	11.5
23	3.55	4.70	6.5	9.2	10.5
24	3.55	4.90	7.1	10.5	12.0
25	3.60	4.95	7.4	12.0	14.3
26	3.60	5.35	8.3	13.2	15.5
27	3.65	5.05	7.3	11.0	12.5
28	3.70	4.85	6.5	8.7	9.5
29	3.80	5.10	7.7	13.8	18.0
30	3.90	5.35	7.5	11.3	13.0
31	3.95	5.50	8.2	14.5	19.0
32	4.00	5.45	7.7	11.2	12.8
33	4.00	5.45	8.0	13.5	15.3
34	4.40	6.00	8.8	14.5	17.5
35	4.55	6.70	9.9	15.5	18.0
36	4.75	6.90	10.7	18.0	21.5
37	4.90	6.60	9.0	12.5	14.0
38	4.90	6.80	9.9	14.7	16.8
39	4.95	7.30	11.3	18.8	22.5
40	4.95	7.60	12.5	21.0	25.0
Average	3.48	4.72	6.7	10.2	11.9

A more significant evaluation of the data is presented in Table II. The footcandle levels required by each observer to obtain specific visibility levels have been obtained from curves of their respective observed data. Thus, for a visibility level of 5, the illumination requirements range from 10 to 88, with an average value of 32 footcandles. It is obvious that observer No. 1 can obtain only a relatively low visibility level with this average illumination. In fact, his data indicate that the visibility of the specific task used in this investigation with 30

TABLE II

Footcandles Required by Each of 40 Observers to Obtain Various Visibility Levels When Viewing a Sample of 8-point Type at a Distance of 16 Inches.

Observer Number	Visibility Level 3	4	5	7	10
1	30.0	56	88	155	275
2	25.0	49	77	145	260
3	23.0	46	71	125	210
4	20.0	38	58	100	170
5	20.0	33	50	89	160
6	25.0	53	86	160	275
7	18.0	33	48	83	140
8	17.5	38	62	120	215
9	14.0	26	42	83	165
10	12.0	24	41	92	195
11	10.5	18	27	47	83
12	10.0	20	37	64	120
13	8.3	20	35	75	165
14	9.0	19	30	55	94
15	8.6	20	35	77	170
16	9.0	18	30	57	110
17	8.0	20	34	69	130
18	8.0	17	28	50	86
19	7.4	16	28	60	130
20	7.2	16	25	46	80
21	6.8	14	23	49	105
22	6.6	14	22	42	79
23	6.3	14	23	47	93
24	6.8	13	21	39	73
25	6.4	13	20	37	63
26	7.1	12	18	31	53
27	6.1	12	20	37	69
28	5.8	12	22	48	115
29	4.8	11	20	35	57
30	4.5	10	18	35	66
31	5.3	10	17	31	53
32	4.8	10	17	33	65
33	4.3	10	17	32	56
34	3.1	8	14	27	48
35	4.2	8	12	22	40
36	3.6	7	11	20	36
37	2.7	6	11	23	50
38	3.0	6	10	21	41
39	2.9	6	10	19	33
40	4.1	7	10	18	30
Average	9.8	20	32	60	111

footcandles will be 3. This means that for the average observer the printed matter corresponds to the visibility of a 5-minute parallel-bar test object viewed with certain standard conditions, but to the low observer it corresponds to a 3-minute test object. On the other hand, if only 10 footcandles are specified for this particular visual task, it is seen from Table I that for observer No. 40 it will have a visibility level of about 5, but for observer No. 1 it will be only 2. Even though there are considerable differences among the observers and in the visibility

level each obtains with a given level of illumination, the relative effectiveness of higher footcandles is about the same. Starting with a visibility level of 4, about a 50 per cent increase in illumination is required for a visibility level of 5 and a three-fold increase will raise the visibility level to 7. With relatively minor variations, this holds true for all 40 observers.

These visibility levels can be converted into equivalent type sizes.[6] If 30 footcandles and a visibility level of 5 are taken as the basis for comparison, visibility levels of 4, 3 and 2 correspond to equivalent type sizes of 6, 4 and 2 points, respectively. In other words, on this basis, a visibility level of 2 indicates that even with 30 footcandles it is as though observer No. 1 were reading 2-point type. Certainly, it is a much more difficult visual task for him than for the other observers. These reduced visibility levels also can be converted into effective decreased contrasts.[7] Thus, if a visibility level of 5 is obtained with a 95-per cent contrast test object, with a specific footcandle level, then visibility levels of 4, 3, and 2, with the same footcandle level, correspond to contrasts of 80, 55 and 30 per cent, respectively.

The footcandle levels required for various percentages of observers to obtain various visibility levels are plotted in Figure 1. These values were derived from Table II. For calculating purposes, the footcandle levels in each column were arranged into seven groups. The percentages have been plotted on a normal probability integral scale. Since the plotted points may be represented by a series of straight lines, normal or Gaussian distributions of the individual footcandle levels are indicated. Thus, the group of 40 observers can be considered representative of a much larger group.

The relationships of Figure 1 represent the percentage of observers who will obtain at least a given visibility level with various footcandle levels. Thus, a visibility level of 5 is obtained by 95, 50 and 5 per cent of the observers with 85, 30, and 11 footcandles, respectively. These relationships emphasize the importance of considering individual subjective variations when determining required levels of illumination. About three times the average footcandle level is required so that 95 per cent of the observers will be able to achieve the visibility level indicated by the average.

Another interpretation can be made from Figure 1. For example, 20 footcandles may be considered for a specific visual task for an average visibility level of 4. However, only 50 per cent of the workers will be expected to obtain the average or expected visibility level. About 25 per cent will have a visibility level of 5 or more, but 10 per cent will

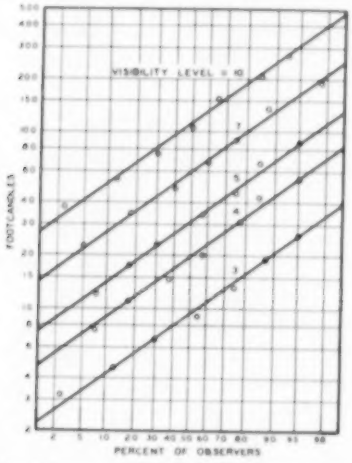

Fig. 1. The relationships between the footcandles necessary for various percentages of observers to obtain given visibility levels.

have a visibility level of 3 or less. If this visual task is a particularly critical operation in a factory and errors may be costly, it is evident that a higher footcandle level will enable more of the workers to achieve a greater certainty of seeing.

It has been shown that differences among individual observers are great. In Tables III and IV are presented data for a representative observer. Visibility measurements were made by observer No. 14 on ten different days. Each datum represents the average of a series of ten individual observations. This was one of the inexperienced observers and the observations of the first day only were included in Tables I and II. The day-to-day variability of a single observer is considerably

TABLE III
Visibility Levels Obtained by a Representative Observer on Ten Different Days

Day	10	20	40	80	100
1	3.10	4.05	5.8	8.9	10.5
2	3.21	4.85	6.1	8.7	10.5
3	3.47	4.72	6.2	8.6	10.4
4	3.33	4.90	6.6	10.0	11.8
5	3.38	4.63	6.2	9.9	12.3
6	3.41	4.63	6.4	9.4	11.7
7	3.30	4.51	5.9	9.7	11.6
8	3.08	3.89	5.2	7.4	8.9
9	3.11	4.18	5.7	8.6	10.3
10	3.31	4.47	5.6	8.7	9.8
Average	3.27	4.48	6.0	9.0	10.8

TABLE IV

Footcandles Required by a Representative Observer to Obtain Various Visibility Levels. Measurements Were Made on Ten Different Days.

	Visibility Levels				
Day	3	4	5	7	10
1	9.0	19	30	55	94
2	8.2	17	27	51	93
3	6.8	15	26	50	94
4	8.0	15	23	43	79
5	7.3	15	25	48	80
6	7.3	15	25	48	83
7	8.0	16	25	48	83
8	9.3	22	38	71	115
9	8.9	19	30	57	97
10	7.4	17	29	58	103
Average	8.0	17	28	53	92

less than was found among the entire group of 40 observers. Furthermore, there is no indication of a learning trend. The average deviation of the ten-day series of observations is about 10 per cent. This compares with an average deviation of about 50 per cent for all the observers. In other words, the average deviation for the latter would indicate that a relatively large increase in illumination would be required before there would be a statistically significant improvement in visibility. On the other hand, the individual data indicate that smaller increases in illumination will be significant. It certainly seems worthwhile to consider individual consistency rather than to emphasize interobserver variability.

While the 40 observers are not uniformly distributed in various age groups, an evaluation of the data does indicate a definite trend towards lower visibility levels for the older observer. This is illustrated in Table V. It is evident that these older observers require a higher footcandle level to obtain a given visibility level than do the younger observers. For example, the 46-55 age group needs about 100 footcandles for a visibility level of 8 as compared with 40 footcandles required by the youngest group. Other comparisons indicate that the two oldest groups require from two to three times more illumination than the 16-25 age group for a given visibility level. This is in general agreement with Weston's results for visual performance which involved speed and accuracy.[8]

This brief summary illustrates the importance of considering individual ability and performance when developing footcandle recommendations for a specific task. If all visual responses were identical, it would be a very simple thing to do. The *apparent* lack of statistical reliability of data should be considered as positive rather than negative information. Averages are useful, but not all informative.

TABLE V
Visibility Levels Obtained by Various Age Groups of Observers with 5 Levels of Illumination.

Age Group	No. of Observers	Footcandle Levels 10	20	40	80	100
16 - 25	11	3.95	5.6	8.0	12.4	14.6
26 - 35	16	3.43	4.7	6.8	10.3	11.9
36 - 45	6	3.58	4.7	6.5	9.3	10.5
46 - 55	6	2.48	3.2	4.5	7.0	8.4
56 - 65	1	2.30	3.0	4.4	6.6	7.5

While this approach is relatively new to evaluating the effectiveness of illumination, it is not new in other fields. In optometry, for example, because the patient can read only 20/40 Snellen, does anyone specify a certain spherical correction without determining causes for this deficiency? Is a 55-year-old patient arbitrarily given an added correction of plus 2.25 diopters for near vision without consideration of many other factors?

It may seem idealistic to specify lighting requirements in terms of individual visual performance. Nevertheless, it is not idealistic in developing a broad concept. To be sure, while it may be practical to test everyone's eyes on this basis, it generally will be uneconomical to provide individualized lighting in typical work-world situations. But, would it not be worthwhile to consider that everyone will benefit from these more adequate footcandle levels? Those who are unfortunate and possess a relatively low visual ability can be raised to a reasonable average level. At the same time the others will be given even better seeing conditions. The mere fact that these levels may be difficult or uneconomical to obtain today should not prevent us from setting them as our goal for the future. Too often the goal of yesterday has become the millstone of today, holding us back from accomplishing what we know should be done. Our ultimate and invariable goal should be the ideal.

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THE STIMULUS TO ACCOMMODATION*

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I. INTRODUCTION

Is accommodation a reflex, is it voluntary, or is it both reflex and voluntary? Fincham[1,11] has recently presented data to support the view that accommodation is a reflex triggered principally by chromatic aberration and/or the Stiles-Crawford effect.

It is the purpose of this paper to present data obtained by the photographic recording of the third Purkinje image from the front of the human lens. In general, the results obtained superficially support Fincham's accommodative reflex theory; however, it appears that sufficient non-retinal cues may have been available to the subject in this experiment to account for the data.

The author takes this opportunity to acknowledge the grant from the American Academy of Optometry which made possible the accommodation recording camera shown in Figure 1.

II. EQUIPMENT

The basic unit is the haploscope formerly decribed in detail.[2] The stimulus to accommodation was presented to the right eye while the left eye was essentially occluded. Three targets[2] in a special Badal optometer system illuminated by white light could be instantly interchanged along the right eye line of sight. These targets were identical in all respects except for the amount of accommodation needed to clear their image on the retina. The target to be viewed was selected by actuating an electromagnetic shutter which occluded one target at the same time it exposed the next target. Only one target was ever visible at a time and the control of the shutters was handled by a master control timer which operated the cameras, shutters, time markers and a fore-warning signal. The operator controlled the timer and could select the sequence of target presentations by a selector switch.

The sequence of stimuli used in this study were from two diopters

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Report of a study done at the School of Optometry, The Ohio State University, Columbus, Ohio. This study was a direct outgrowth of preliminary experiments undertaken with the aid of a grant for research from the Univis Lens Company, Dayton, Ohio.
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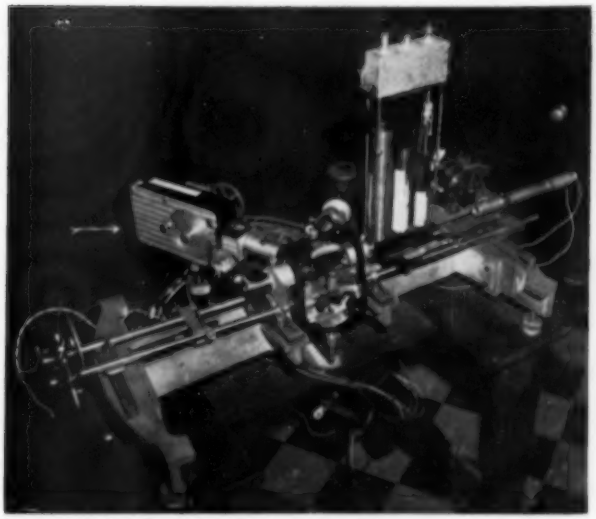

Fig. 1. Accommodation Recording Camera. The film moves upward continuously at a half inch per second past a horizontal slit. The change of the stimulus was marked on the film by a rotary solenoid rotating a transparent plate of glass in the light path which shifted the whole record laterally.

to zero diopters or from two diopters to four diopters. The two diopter stimulus was always presented initially for at least 2 seconds. This was followed by the zero or the four diopter stimulus depending on the predetermined order of presentation used by the operator in setting the selector switch. This order was unknown to the subject and was as follows: 2-0, 2-4, 2-4, 2-0, 2-0, 2-4, 2-0, 2-4, 2-4, 2-0.

Accommodation was photographically recorded by means of the camera shown in Figure 1. The size of the reflected image from the front surface of the crystalline lens was recorded on a continuously moving film. A typical film record of accommodation is presented in Figure 2. The response of the right eye only was recorded. Convergence was simultaneously recorded by a specially modified A.O. Ophthalmograph,[2] which recorded the image produced by reflection at the corneas of both eyes.

Both cameras were equipped with optical film markers which shifted the record laterally at the moment the stimulus to accommodation was changed. The film traveled vertically in both cameras and both cameras were provided with narrow slits before the film plane to eliminate possible time errors from vertical eye movements. The film speed in each was one-half inch per second.

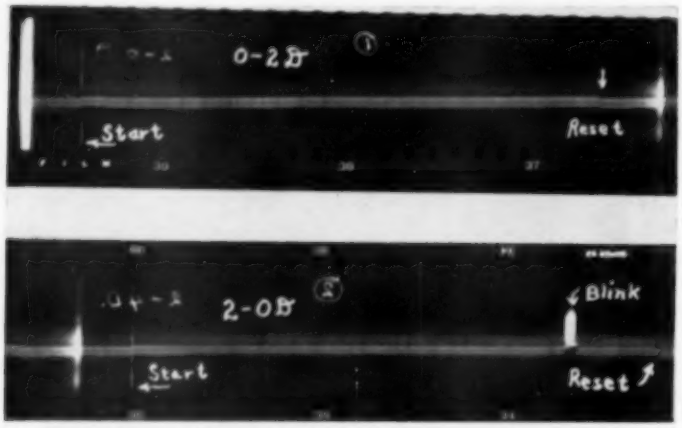

Fig. 2. A pair of sample film records showing the response of accommodation. These films are records 1 and 2 plotted in Figure 6. Note the essentially blurred nature of the record obtained.

The accommodation calibration curve shown in Figure 3 was obtained by photographing the image from the front surface of the lens of the eye when the eye was accommodated a predetermined amount, as determined by means of a Fry optometer.[8]

The convergence calibration curve of Figure 3 was determined by photographing the eye positions for each of several convergence stimuli. The right eye was kept straight ahead by fixating the accommodative stimulus target while the left eye was brought into the required convergence by means of a similar target presented to the left eye. The criterion of proper convergence was the fusion of the right and left eye targets. Since only the right eye fixated the accommodation target during the experiment, the degrees of change of the left eye, due to accommodative convergence, could be obtained from the calibration curve. The subject required an Rx: O.U. —0.75 D. sph. ⌒ —0.50 D. cyl. axis 180. A —1.00 D. sphere (without the cylinder) was adjusted into the optics of the haploscope to provide the subject with a reasonably clear view of the target and to permit photography without obstructing lenses. A biting board was used.

IV. EXPERIMENTAL PROCEDURE

The subject was Richard Kelly, age 29, a relatively skilled observer currently enrolled as a senior optometry student at the Ohio State University. His distance phoria was 2Δ exophoria; his A.C.A. measured 4.9; his corrected visual acuity was 20/15. During the experiment

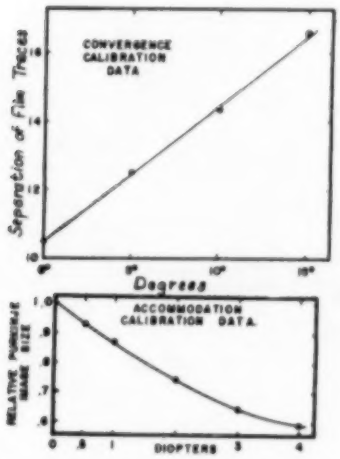

Fig. 3. The upper curve gives the convergence calibration data and shows the relationship between the separation of the left and right eye records for various amounts of convergence.
The lower curve is the accommodation calibration data and shows the relationship between the relative size of the image reflected at the front surface of the lens and the diopters of accommodation in play.

his right pupil was dilated with neosynepherine which stimulates the radial muscle fibers of the iris. The dilated pupil permitted a clearer film record of the changes in curvature of the lens.

Preliminary practice was provided before any data were gathered and the subject's performance was observed on the focusing screen of the ophthalmograph. He learned to clear the image as quickly as possible when the stimulus was presented and to rely on an automatic 1½ sec. tactile fore signal to prepare himself for the stimulus change. During the last practice session, the cameras were turned on and in the remainder of the session the stimulus sequence followed the random order described above. Since the cameras were virtually silent, and since a noisy motor generator was running, the subject did not know when the data were being recorded.

Figure 4 shows the projector system used to transcribe the film data onto paper. This arrangement permitted the ordinates to be magnified any amount without enlarging the abscissa values. The accommodation records were thus magnified laterally by 50 times without changing the time scale. This differential magnification facilitated the determination of the inflection points on the accommodative data films.

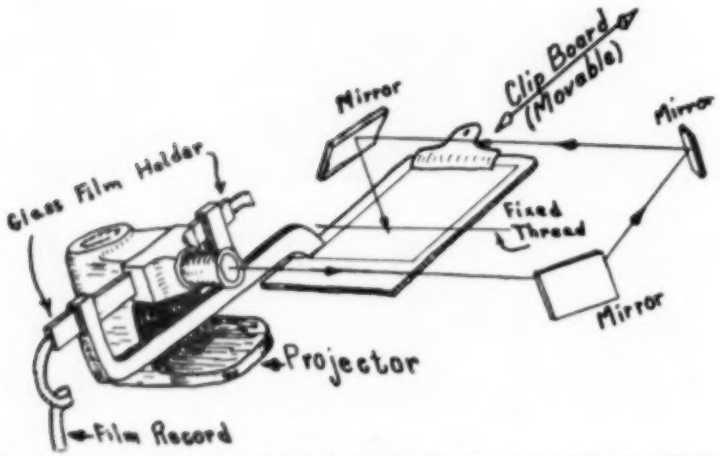

Fig. 4. Projector Arrangement for Analyzing the Accommodation Records. The film and paper on the clip board are yoked together as shown. The film image (magnified 50 times) was reflected onto the paper by the 3 mirrors. The fixed thread provides the reference line at which the Purkinje image sizes were determined by pinpoint marking the paper.

V. RESULTS

Figure 5 shows the sequence of 10 responses obtained in the random series. The left-hand group of curves shows the response to a stimulus change from 2 to 0 diopters. The right-hand group shows a stimulus change from 2 to 4 diopters. The sequence of taking the curves is shown by the number encircled on each individual graph. The convergence scale is on the left and the scale marks are on the outside of the individual graph frame. The accommodation scale is on the right and the scale marks are inside the graph frame. Accommodation is plotted as a series of dots while convergence is plotted as a line.

The accommodation data have been plotted without correcting the diopter scale to make it linear. This greatly compresses the range from 3 to 4 diopters as compared with the range from 1 to 2 diopters and makes a direct comparison with convergence impossible. However, it is still possible to see the relative similarities and differences between the accommodation and convergence response curves.

Figure 6 shows two convergence response curves from a second series of twelve findings. These particular curves record the subject's mistake of accommodating when he should have relaxed. The mistake was soon recognized, however, and the correct response initiated as shown.

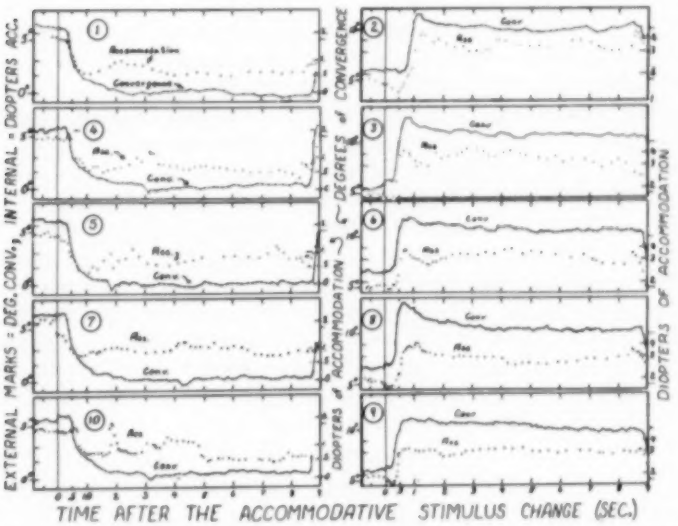
EXTERNAL MARKS = DEG. CONV. INTERNAL = DIOPTERS ACC.
DEGREES of CONVERGENCE
DIOPTERS of ACCOMMODATION
DIOPTERS OF ACCOMMODATION
TIME AFTER THE ACCOMMODATIVE STIMULUS CHANGE (SEC.)

Fig. 5. Results of the Ten Random Series Accommodative Responses. The fluctuations in the accommodation curves are in part due to the errors of reading the blurred images on the film. The standard error of each point near 4 diopters is ± 0.6 D; 2 diopters is ± 0.11 D, and ½ diopter is ± 0.1 D.

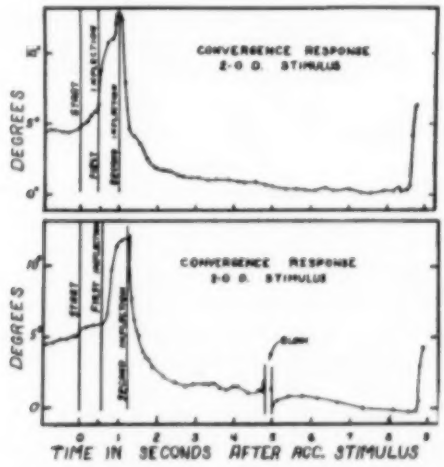

Fig. 6. Error Responses Showing Accommodation (Inferred from the Convergence Response) when Relaxation was Indicated.

DISCUSSION

The equipment and procedure were designed to minimize all accommodative cues except blurredness. For example, the targets did not change size, color, brightness or lateral position and no binocular parallax was present. The sequence of accommodative changes was randomized and the controlling switch was interspersed with a dummy switch to try to eliminate the audio cues.

The data, Figure 5, presented from a complete experiment of 10 trials, show no accommodative response errors. This remarkable performance, at first glance, seems to offer positive proof of the Fincham postulate that the organism knows which way to go because of some cues provided by the rays of light converging onto the retina. However, during practice sessions, the author noted that incorrect changes in accommodation occurred frequently, as evidenced by incorrect movements of convergence. Figure 6, from a separate series of 12 random presentations, shows the clear cut nature of these incorrect responses. Unfortunately, the associated accommodative records of this series were unuseable because of pupil interference, but it can be inferred that so great a change in convergence must certainly have accompanied a corresponding change in lens curvature. The actual recorded data (including the separate series of 12) totals 22 responses, of which only 2 were in the wrong direction.

The fact that there were any wrong responses at all argues against the reflex control of accommodation. Also, it must be remembered that subtle auditory clues in the form of slight differences in the sound of the dummy and the control switches may have been used and that the operator may inadvertently, by movements or timing, have supplied to the subject adequate cues as to the direction of the forthcoming stimulus.

Indeed, the subject professed no confusion during the experiment and implied that he did listen to the switches and that he did try to out-guess the operator. This is in contradistinction to the experiences of two other trained observers who made observations on the same experiment and became extremely frustrated to the point that the accommodative response effort became very difficult and the reaction time was much increased. This subject's uncorrected astigmatism could have provided an effective clue as to whether to relax or to accommodate, which was not available to the other two trained observers.

Further evidence in support of a willed or voluntary control of accommodation as distinct from a reflex is presented by the following facts. The minimum voluntary reaction time to a visual stimulus is of

the order of 0.180-0.200 seconds.[4] The average reaction time of accommodative convergence throughout the data presented is 0.249 seconds and therefore appears to be voluntary. The subject's correction of his response (Figure 6) following the onset of the wrong response is delayed by an average of 0.621 seconds more, which is 0.372 seconds longer than this subject's reaction time for accommodative convergence. Compare this with the reflex blink reaction time to a strong light stimulus or to a menacing movement of 0.061 to 0.132 sec.[5, 6] Even the relatively long reaction time of a fixation reflex (0.195 sec.[7]) is 0.426 sec. shorter than the time needed for the subject to correct his response. All of the correct accommodative responses (reflexes?) averaged a reaction time of 0.343 seconds. If the accommodative response were reflex in nature, it seems reasonable that a correction in the faulty response should have occurred within 0.34 second instead of 0.621 second as observed. Furthermore, some of the records seem to show anticipation of the stimulus change even before it has occurred, apparently as a result of clues other than optical influencing the voluntary control.

From clinical experience and from research studies we know that the depth of focus tolerated by the subject using only one eye is a function of the detail of the task and the attitude of the subject; that is, his interest, cooperativeness and the instructions he has received. The expression, "lazy lag of accommodation" has been aptly used to describe this error of accommodation. An accommodative reflex control mechanism probably would not be so flexible.

From the foregoing it can be seen that an experiment designed to settle the problem of the control of accommodation must be more sophisticated even than this one. While it seems intuitively true that the control of accommodation has an unconscious phase, the nature of that control has yet to be determined, whether it is the awareness of target nearness, the desire to keep the image clear or a real reflex mechanism involving chromatic aberration and the Stiles-Crawford effect as suggested by Fincham.

The data presented offer some evidence for a second kind of accommodative control, not associated with convergence. This may be inferred from the fact that many fluctuations of accommodation occur, apparently without any corresponding convergence changes, as in Figure 5. These fluctuations are of low amplitude and are slow. They possibly could be due to a fluctuating sympathetic innervation. Since the experiment was conducted with a sympathomimetic drug (neosynepherine) the normally slight fluctuations in the sympathetic innervation may be highly magnified by the hypersensitivity produced by the drug of the

muscles innervated by the sympathetic. Other possible explanations include fluctuations due to the errors of measurement, due to the pulse or due to respiration.

At the present it is believed that sympathetic control of accommodation exists but is only of minor importance and, thus, it is usually ignored in the clinical evaluation of the relationship between accommodation and convergence. It may contribute to such phenomena as night myopia, psychic convergence and instrument myopia.

PRACTICAL IMPLICATIONS

Inasmuch as further study will be necessary to prove conclusively what the mechanisms of accommodative control really are, let us review what we know and let that be our clinical guide. 1. We know that blurredness of the retinal image must be a stimulus to accommodation, or else any Badal optometer system as popularly used in physiological optics research would not work to stimulate accommodation. 2. We know that psychic control of accommodation is a real factor as shown by the recent work of Ames and Ittleson[9, 10] and as shown by the differences between the data from the clinical type of eye examination and the stereoscopic type test and screening devices. 3. We know that attention is important as shown by the shift toward esophoria at near when the patient is requested to really look at the smallest test letters to be sure they are clear.

These principals may be used, for example, to test for the amplitude of accommodation. The patient should be given the test card to hold in both hands which should positively establish by kinethesis the increasing nearness of the card during the push up to the amplitude limit. He should be instructed to do his very best and to keep the smallest letters really clear as long as possible. This should establish his set or attitude toward the test. Finally, any blurredness of the retinal image resulting as he approaches the punctum proximum may stimulate further accommodative effort so that a good estimate should be obtained of the patient's accommodative ability with all known stimuli to accommodation in play.

SUMMARY AND CONCLUSIONS

A study of the accommodative responses to a random series of accommodative stimuli is described. Accommodation and convergence were both recorded photographically. Two records out of 22 showed that the subject initially made wrong responses to the stimuli presented. The following conclusions were reached.

1. Consideration of the reaction times indicates that the wrong accommodative responses probably were not corrected on the basis of a

reflex, but rather on the conscious awareness of a mistake in the direction of the response.

2. Clues other than blurredness of the retinal image could have been used by the subject to help him make 20 out of 22 correct responses and thus the accommodative responses were not necessarily reflex in nature.

3. Some evidence of an active control of accommodation not of parasympathetic origin, was revealed by fluctuations of accommodation apparently unattended by fluctuations of convergence.

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ANNOUNCEMENT

BACK ISSUE NEEDED FOR SCIENCE MUSEUM LIBRARY

The Science Museum Library, London, is in need of the February, 1943 (Volume 20, Number 2) issue of the AMERICAN JOURNAL OF OPTOMETRY to complete their sets of annual volumes of this publication and to permit their holdings to be bound for permanent use.

Optometrists on either side of the Atlantic who are able to supply this single issue are urged to write or send same direct to Miss H. J. Parker, Deputy Keeper of the Library, Science Museum Library, South Kensington, London, S. W. 7, England. File number S.8831.

We at the Journal office have on hand most of the back issues of this publication, and we regret that the February 1943 issue is now out of print. Assistance in this matter will be appreciated.

CAREL C. KOCH

SPECIAL REPORT

RESOLUTIONS DEALING WITH INTERPROFESSIONAL RELATIONS*

Carel C. Koch†
Minneapolis, Minnesota

The official position of optometry in its relationships with ophthalmology was clearly defined in resolutions adopted by the American Optometric Association, House of Delegates, at Milwaukee, Wisconsin, during the 58th annual Congress, July 6-9, 1955.

In these resolutions which follow, the attitude of optometry towards ophthalmology is voiced, and the profession in the future is pledged to observe the positions taken. These resolutions should remove the regretable uncertainty which resulted from the action of the House at Seattle in 1954.

RESOLUTION NO. 5 — (1955)

WHEREAS, it is the desire of the American Optometric Association to clarify the purposes and objectives of Resolution No. 4 adopted by the House of Delegates assembled at Seattle on June 25, 1954, since that resolution led to deliberate misrepresentation by some, and justifiable misunderstanding by others; and

WHEREAS, the purpose of both optometry and ophthalmology has been, and is to give the best professional care to the public, and any misunderstanding between ophthalmology and optometry can only work to the detriment of the public and of both professions; now, therefore, be it

RESOLVED, first, that the American Optometric Association does hereby declare that it is not the intention of the profession of optometry to eliminate exemption, now granted ophthalmology;

RESOLVED, second, that the American Optometric Association does hereby declare that it is not the intention of optometry to enter into or engage in the practice of ophthalmology; and the American Optometric Association reiterates and reaffirms Resolution No. 3 adopted at the 41st Annual Congress on June 26, 1938, which reads as follows:

"WHEREAS, the physiological eye care known as optometry, and

*Submitted on July 20, 1955, for publication in the August, 1955, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.
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surgical eye care known as ophthalmology are two separate and distinct professions, each requiring the whole time, thought and attention of the practitioners of each respective art and science; now, therefore, be it

"RESOLVED, that the American Optometric Association goes on record as desiring the complete cooperation of the two professions, with emphasis on the fact that optometry has no desire to extend its practice to include any limited or other form of medical eye care."

RESOLVED, third, that it is the policy of the American Optometric Association that all activities of technicians in the field of vision care shall be personally directed and supervised by an optometrist or ophthalmologist, and limited to purely mechanical procedures;

RESOLVED, fourth, that it is the policy of the American Optometric Association that a refraction or visual analysis can not be properly done by a technician because professional discretion and judgment are always necessary to achieve a satisfactory result for the patient;

RESOLVED, fifth, that the American Optometric Association maintains that the exercise of professional judgment and discretion cannot be delegated to technicians to resist every effort to grant privileges to technicians by exemption, and that it will continue to oppose encroachments by lay technicians;

RESOLVED, sixth, that optometry believes that the fields of ophthalmology and optometry are broad and sufficiently defined to permit both professions to engage in interprofessional relations so that the public will enjoy the benefits of such relationship and continue to receive the best visual and eye care in the world.

RESOLUTION NO. 6 — (1955)

WHEREAS, it is in the public interest that the various health professions meet and discuss the various problems which affect the public health; and

WHEREAS, many of these problems concern more than one profession; now, therefore, be it

RESOLVED, that the Board of Trustees of the A.O.A. take such steps as may be necessary to create or expand interprofessional relations with all the professions or groups concerned with the public health or welfare; and, be it further

RESOLVED, that the state associations be encouraged to take steps to create similar relations on a state and local level.

The foregoing resolutions were unanimously adopted by the

A.O.A. House of Delegates. In addition these were adopted without prolonged discussion. Thus the action of the A.O.A., in official session, offered a marked contrast to the animosity displayed by certain ophthalmological leaders during the meeting of the Section on Ophthalmology of the A.M.A. in June, 1955, at Atlantic City.

As is known to many optometrists, the writer has spent much time conferring on interprofessional problems and it was particularly gratifying to watch the seasoned and skilled approach to the current problems displayed by A.O.A. officers and delegates at this recent meeting.

It is a further cause for gratification that the A.O.A. acted as it did, *after* becoming aware of the Atlantic City fiasco. The poise and maturity of the optometric delegates at Milwaukee indicates the high standards of optometric leadership evidenced throughout A.O.A. State delegations.

It is hoped that these A.O.A. resolutions will prove helpful in bridging the gap that now exists between the official bodies representing the practitioners in the important field of eye care.

BOOK REVIEW

ADVANCED SURGERY OF CATARACT. Daniel B. Kirby, M.D., F.A.C.S. J. B. Lippincott Company, Philadelphia. 271 pages. 138 figures. 96 illustrations. Cloth. $27.00. 1955.

This book contains a section on adaptation to cataract lenses from the *point of view of the patient* which should be read by everyone who fits them. Without personal experience in getting used to it himself the optometrist or ophthalmologist has little idea of the annoyance and imperfections of vision experienced with even the most expertly fitted cataract glasses. This section alone is worth a great deal to ophthalmic practitioners.

There is also a wealth of material on the surgery of cataract. Many new techniques and attitudes toward various surgical procedures are presented. Informative material of interest to the optometrist includes the preparation of the patient for surgery, causes of failure in cataract operations, early recognition and treatment of complications and preservation of the round, active pupil. Extra capsular and intracapsular extraction of the cataractous lens are described in detail and a good deal of space is devoted to complications of cataract surgery.

The author, the late Dr. Daniel B. Kirby, was a well known

authority on the subject and was internationally recognized for his outstanding work. A previous book, "Surgery of Cataract" was widely used and very highly regarded. The present volume, which Dr. Kirby completed less than a day before his decease, is a worthy addition and seems sure to receive as wide and favorable acceptance because of its own excellence.

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CORRESPONDENCE

THE INCONSTANCY OF THE ACA RATIO

To the Editor: Dr. Leo Manas has reported in his recent paper[1] that his measurements of the ACA ratio showed a certain variability. His data are clinical data and subject to the criticism that the "true" relationship between accommodation and accommodative convergence may still be a constant one.

The criticism may in part be obviated by more refined measuring techniques. A recent attempt by the present writer to do this[2] yielded results which are in essential agreement with Manas' findings. There is little doubt that even haploscopically determined data points have a considerable range of uncertainty. Yet even they may still not be inconsistent with a rigidly constant "underlying" ACA.

At some stage, however, we have to ask ourselves what we mean by the "true" ACA. Can we continue to maintain that while the measurements show various degrees of scatter, the "underlying" or "true" relationship is linear or constant and that if we had better measurements we would uncover it?

The only way of being sure of what the relationship is between accommodation and accommodative convergence, is by measuring it. In other words, when accommodation and convergence measurements have reached their absolute limit of precision we will have to call a halt to the argument and state what has been found. Experimentally we can then go no farther and theory without experiment in this field seems rather pointless.

[1] Manas, Leo. The Inconstancy of the ACA Ratio. Am. J. Optom. & Arch. Am. Acad. Optom. 32.6.304-315, 1955.
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The direction in which research in this field must go is clearly that of better and more precise simultaneous measurements of accommodation and convergence. It may be that—as far as accommodation is concerned, at least—improvements in measurement over those presently available will not be readily achievable. We may thus soon find ourselves confronted with a sort of Heisenberg Uncertainty Principle as applied to an accommodation/convergence measurement: simultaneous measurements of the two functions cannot be obtained with a precision better than a given value. It is hoped that when that time arrives, we will have accommodation/accommodative convergence scattergrams with a higher degree of central tendency than the present ones.

Those hardest hit by the present findings, incidentally, are not the clinicians but the theorists. The clinician will continue to find the straight line drawn through the distant and near phorias a helpful guide to visualizing the tendency of convergence to increase with accommodation. But it is clearly quite difficult to demonstrate changes in the ACA, be they developmental or due to specific agents or procedures, if the variability is of the currently accepted extent.

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CURRENT COMMENTS

Terry Judith Parkins
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department; such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

AO H-R-R COLOR TEST

American Optical Company Instrument Division, Buffalo, is now distributing the AO H-R-R Pseudoisochromatic Plates. This color perception test is the result of a 13-year research program, and of a production process that was two years in the making.

The test encompasses three major functions in color vision testing. It screens those with abnormal color vision from the normal subjects; it determines the type of color deficiency, and the extent of the deficiency.

The test comprises 24 plates, four of which are for demonstration, six screening plates for detection of red-green or blue-yellow color vision deficiency, 10 qualitative and quantitative plates for diagnosing red-

green defects, and four qualitative and quantitative plates for diagnosing blue-yellow defects.

The test was devised by LeGrand H. Hardy, M.D., Gertrude Rand, Ph.D., and M. Catherine Rittler, B.A. Their work was carried out at Knapp Memorial for Physiological Optics at Columbia University, with the support of the university and the U. S. Office of Naval Research.

The plates are so designed that the test cannot be memorized: the simple symbols, cross, circle and triangle, can be identified by children or illiterates: each plate is identical in basic design to every other one, and all four quadrants of each plate are identical, permitting variation in placement of pages in the books. The test has been approved by the Intersociety Color Council and the armed services.

CLINICAL COURSE IN STRABISMUS BY FLOM

On June 18, 19, and 20, Dr. Merton C. Flom, of the University of California School of Optometry, presented a special clinical course in strabismus to Washington State optometrists at the Olympic Hotel in Seattle. The course, consisting of 18 hours of lecture and demonstration, and 6 hours of clinical work, was divided into four parts: Part I (Fundamental Concepts in Strabismus), Part II (Clinical Examination and Diagnosis of Strabismus), Part III (Prognosis and Treatment of Strabismus), and Part IV (Actual Examination of Patients with Strabismus). Dr. Flom, Fellow of the American Academy of Optometry and Research Fellow of the American Optometric Foundation, included in the course the practical and clinical developments which have thus far been derived from the Academy-sponsored University of California Strabismus and Orthoptics Study.

GRADUATE PROGRAM IN PHYSIOLOGICAL OPTICS

The graduate program in Physiological Optics at Indiana University has been extended to include the offering of the Ph.D. degree. This program is provided by the Graduate School in co-operation with the faculty of the Division of Optometry. It is designed primarily for graduates of optometry curricula wishing to prepare themselves for teaching and research in the field of vision. The Graduate School Committee for the program in physiological optics consists of Professors H. W. Hofstetter (chairman), Merrill J. Allen, and J. S. Rafalko.

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ACADEMY POST-GRADUATE COURSES IN CHICAGO NEXT DECEMBER

In this issue the Academy presents the detailed outline of the post-graduate courses that will be offered the profession in Chicago next December. See pages 440 through 448.

This is the first year that the Academy has attempted such an impressive educational program for optometrists. These three days of post-graduate work will precede the regular four day Academy session which, as usual, will be packed with important original papers dealing with the clinical and theoretical aspects of optometric work.

The interest shown by optometrists in this special three day pro-

gram of post-graduate courses will determine whether or not to continue, drop or expand this program.

In this first excursion into the field of actual post-graduate class work, the Academy is being guided, to some extent, by the splendid response given in ophthalmology to similar courses offered each Fall by the American Academy of Ophthalmology and Otolaryngology. Their courses, including all eye and ear pathology—covering both diagnosis and treatment, are attended annually by several thousand specialists and are looked upon by these men, who attend each year, as the most authentic method of keeping up to date in their practice techniques. The courses outlined here, devised for optometrists by the American Academy of Optometry, are planned to serve the same broad purpose.

Dr. V. J. Ellerbrock, member of the faculty of the School of Optometry, The Ohio State University, has, with the assistance of a strong committee, organized a group of 40 specialized courses. Each is staffed by an experienced lecturer who has specialized in his subject. These men will present their material during the three days immediatedly prior to the actual meeting of the Academy. The dates for these graduate courses are December 7, 8 and 9, and will run from 8:00 A. M. until 9:30 P. M. Optometrists from the U. S. A. and Canada may enroll for one or more of the 40 courses offered. This specialized graduate work will be presented in Chicago at the Drake Hotel and all members of the profession are invited to register.

A review of the list of optometrists, educators and scientists who will conduct these post-graduate courses shows many of the foremost specialists in optometric education among the lecturers. For this reason, the Committee that has arranged these courses is to be congratulated in securing such excellent talent and the lecturers themselves deserve our thanks for this contribution to post-graduate optometric education.

Registration for these courses may now be made through Dr. D. G. Hummel, chairman, Committee on Administration, 418 National City Bank Bldg., Cleveland, Ohio. Those wishing to register should direct their letters and checks to Dr. Hummel. As the enrollment is limited to 30 persons in each one hour class, optometrists are urged to enroll at once to assure places in the classes of their choice.

CAREL C. KOCH

TRANSACTIONS OF THE
AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data, news, professional problems and ideals, as these relate to the Academy.

AMERICAN ACADEMY OF OPTOMETRY POST-GRADUATE COURSES

Drake Hotel - December 7, 8, 9, 1955, Chicago

V. J. Ellerbrock, Chairman
Committee on Instruction

D. G. Hummel, Chairman
Committee on Administration

GENERAL INFORMATION ON POST-GRADUATE COURSES

Time: All courses are scheduled for the three days immediately preceding the regular annual meeting of the Academy.

Place: All of the courses will be taught in the Drake Hotel unless otherwise designated.

Applicants: Any optometrist may apply for one or more courses; however, members of the Academy have preference until October 15, 1955.

Cancellation: In case of cancellation the fee will be returned, providing such cancellation is received no later than November 19, 1955.

Cost: The cost per hour of instruction is $2.00 unless otherwise specified.

Enrollment: For most of the courses the enrollment is limited to 30. Several very specialized courses, however, are limited to ten participants.

Number of Courses: Forty (40).

Hours of Instruction: One hundred and four (104).

Applications: All applications should be sent to Dr. D. G. Hummel, 418 The National City Bank Building, Cleveland, Ohio.

Deposit: One-half the total fee for each course must accompany the application. The balance must be paid at the commencement of the courses.

Tickets: Without exception, everyone enrolled in a course must register and pick up the appropriate ticket. Without it, no one can be admitted.

Lecture Rooms: These will be posted at the registration desk. The hotel bulletin board will state the location of the registration desk.

KEY TO DESIGNATION OF PERIODS

Time	Wednesday	Thursday	Friday
8:00 A.M.	W-8	T-8	F-8
9:00	W-9	T-9	F-9
10:00	W-10	T-10	F-10
11:00	W-11	T-11	F-11
12:00	W-12	T-12	F-12
1:00 P.M.	W-1	T-1	F-1
2:00	W-2	T-2	F-2
3:00	W-3	T-3	F-3
4:00	W-4	T-4	F-4
5:00	W-5	T-5	F-5
7:30	W-E	T-E	F-E

Course 1
Legal Aspects of Optometry
Morton L. Abram, Ll.B., D.O.S.
Chicago, Ill.
A two-hour course—$4.00
Periods: W-9, W-10.

The legal development of optometry will be traced in accordance with a comprehensive outline. The legal basis for regulation of optometry will be covered, defined and distinguished from the legal regulation of optometric functions. Case method will be followed, i.e., actual cases will be used to illustrate legal aspects of optometry. Also to be covered will be malpractice and the functions of the expert witness in court.

Course 2
Raubitscheck Arrow Test for Astigmatism
Merrill J. Allen, O.D., Ph.D.
Bloomington, Ind.
A one-hour course—$2.00
Period: T-9.

Some of the tests for astigmatism will be reviewed and evaluated. In comparison, the Raubitscheck test will be described and its advantages will be discussed. There will be practical demonstrations of the Raubitscheck test technique.

Course 3
Amblyopia, Suppression and Related Phenomena
Neal J. Bailey, O.D., Ph.D.
Bloomington, Ind.
A two-hour course—$4.00
Periods: T-10, F-10.

A central problem in the diagnosis and prognosis of cases presenting anomalies of binocular integration is the existence of suppression. The relationship of suppression to amblyopia and other anomalies will be discussed from the point of view of etiology and from this the principles of treatment of such cases will be developed.

Course 4
Problems of Anisometropia
Robert E. Bannon, O.D.
Southbridge, Mass.
A one-hour course—$2.00
Period: W-1.

The spectacle correction of anisometropia is a frequent source of difficulty since it may introduce undesirable prismatic effects, difference in image size, and anomalous binocular space perception. The course will review axial and dioptric anisometropia; prismatic effects; anisophoria; aniseikonia and space perception; prescribing of prisms, iseikonic lenses, and compromise corrections.

Course 5
Presbyopic Additions—Physiological Basis
Robert E. Bannon, O.D.
Southbridge, Mass.
A one-hour course—$2.00
Period: T-1.

This course will review the various ocular factors and how they may be measured in routine clinical practice. Consideration will be given to the determination of near point prescriptions based upon these data and the patient's individual needs.

Course 6
Oblique Astigmatism
Robert E. Bannon, O.D.
Southbridge, Mass.
A one-hour course—$2.00
Period: F-1.

Data on the frequency of oblique astigmatism will be presented and the role of oblique astigmatism upon binocular spatial localization will be discussed. Typical case records and suggestions for prescribing will be offered. Consideration also will be given to certain clues by which spatial localization difficulties may be detected.

Course 7
Design of Eikonic Lenses
Edwin W. Bechtold, O.D.
New York, N. Y.
A four-hour course—$8.00

Periods: T-9, T-10, F-9, F-10.

Translation of eikonometer findings into a final prescription and the design of correction lenses will be developed at length. The procedure for designing single and bi-toric lenses also will be outlined. Special emphasis will be given designs of lenses that can be fabricated by local laboratories.

Course 8
Visual Screening of School Children
Lois B. Bing, O.D.
Cleveland, Ohio

A two-hour course—$4.00

Periods: F-11, F-12.

Problems involved in visual screening of school children will be considered: present screening procedures will be analyzed; currently available screening instruments will be discussed and criteria for referral established.

Course 9
Visual Efficiency and Industrial Performance
C. S. Bridgman, O.D., Ph.D.
Madison, Wisconsin

A two-hour course—$4.00

Periods: W-2, W-3.

The relations between vision and industrial performance and safety will be summarized, along with methods of providing optimum visual environment and visual efficiency.

Course 10
Streak Retinoscopy
Jack C. Copeland, O.D.
Chicago, Ill.

A four-hour course—$16.00

Periods: W-4, W-5, T-4, T-5.

The following outline describes the steps of the presentation:

1. Determination of the neutral point.
2. Detection of low astigmatic errors.
3. Locating the zone of the astigmatic band.
4. Determining the power of the cylinder.
5. Estimating the type and degree of error without lenses.
6. "Guide Angle" technic, in refining axis position.
7. Minus cyclinder procedure.
8. Comparison of streak retinoscopy with standard retinoscopic procedures.

Course 11
Design in Eyewear
Margaret S. Dowaliby, O.D.
Los Angeles, Calif.

A two-hour course—$4.00

Periods: T-2, F-2.

Design of modern eyewear as related to patient's facial features, coloring, etc. Particular attention will be given to the role of eyewear in the feminine wardrobe; wherever possible actual demonstrations will be provided.

Course 12
The Design and Fitting of Contact Lenses
Jack Neill, O.D.
Philadelphia, Pa.
William Feinbloom, O.D., Ph.D.
New York, N. Y.
William Policoff, O.D.
Wilkes-Barre, Pa.

A twelve-hour course—$48.00

Periods: W-9, W-10, W-2, W-3, T-9, T-10, T-2, T-3, F-9, F-10, F-2, F-3.

A comprehensive course in the principles, design, and fitting of modern contact lenses. A considerable part of the course will be devoted to practical problems of fitting.

Course 13
Visual Rehabilitation of the Partially Blind
William Feinbloom, O.D., Ph.D.
New York, N. Y.

A four-hour course—$8.00

Periods: F-4, F-5.

This course will present the role of the optometrist today in the field of rehabilitation. The history, purpose, and present organization of the blind and partially blind agencies in this work will be reviewed.

It now has been amply demonstrated that it is desirable for optometrists to be associated with these agencies. The *modus operandi* for such cooperation will be explained.

The sociological, psychological, and educational problems involved with various optical aids also will be presented.

Course 14
Optics of Contact Lenses
Bernard Rossett, O.D.
New York, N. Y.
Isidore S. Finkelstein, O.D., Ph.D.
New York, N. Y.

A four-hour course—$8.00

Periods: T-4, T-5, F-4, F-5.

The course will cover the following subjects: 1. Contact lenses in isometropia and in anisometropia. 2. Contact lenses in aphakia. 3. Contact lenses in aniseikonia. 4. Contact lenses in subnormal vision and accommodation. 5. Prescription and laboratory computations for contact lenses.

Course 15
Physiological Basis of Discomfort from Glare
Glenn A. Fry, O.D., Ph.D.,
Columbus, Ohio

A one-hour course—$2.00

Period: F-9.

Relative to discomfort from glare, the course includes:

a. Review of basic data.

b. Role of the iris.
c. The role of the optometrist in providing relief.

Course 16
Analysis of Problems with Retinoscopy
Glenn A. Fry, O.D., Ph.D.
Columbus, Ohio
A one-hour course—$2.00
Period: F-3.

The following subjects are covered in this course: Methods of combatting reflections from lens surfaces; interpretation of scissor motion and unusual types of reflexes; interpretation of discrepancies between subjective and retinoscopic findings.

Course 17
Non-glass Ophthalmic Lenses
Robert Graham, O.D.
Pasadena, Calif.
A one-hour course—$2.00
Period: T-1.

Advantages and limitations of modern plastic lenses—where they should and should not be used—and how to utilize them for optimum results.

Course 18
Contact Lenses Currently in Use
Robert Graham, O.D.
Pasadena, Calif.
A one-hour course—$2.00
Period: F-1.

Discussion of 12 significant types of contact lenses currently in use.

Course 19
The Stereoscope as an Orthoptic Instrument
Salvi S. Grupposo, O.D.
Southbridge, Mass.
A one-hour course—$2.00
Period: W-E.

Many modern orthoptic or visual training instruments are essentially elaborations of simple Wheatstone or Brewster stereoscopes. This course will present a review of these stereoscopes with special reference to their optical principles and applications. Practical examples in the design of various types of instruments will be given.

Course 20
Recommended Lighting Levels and Their Measurement
Sylvester K. Guth, E.E., D.O.S.
Cleveland, Ohio
A two-hour course—$4.00
Periods: W-4, W-5.

The course will cover: a. language of lighting; b. lighting recommendations; c. lighting systems; d. lighting surveys.

Course 21
Office Diagnosis of Color Defects
Gordon G. Heath, O.D.
Berkeley, Calif.
A two-hour course—$4.00
Periods: T-8, F-8.

Characteristics of the various types of defective color vision; what the color-blind see; recent advances in clinical methods of testing; simple diagnostic instruments and techniques; remedial measures to aid the color-defective.

Course 22
The Elements of Statistical Reasoning
Monroe J. Hirsch, O.D., Ph.D.
Ojai, California
A four-hour course—$8.00
Periods: W-2, W-3, T-3, F-3.

Another title for this course would be "Statistics Necessary for the Understanding of Scientific Publications" and it is presented from the point of view of the man who has had no formal training in statistics and who feels the need for such a course in order that he may understand papers read at Academy meetings and published in our *Journal*.

The descriptive statistics such as mean, median, standard deviation, and correlation coefficient will be described. The concept of probability will be dealt with more fully, as will the chi square technique.

Course 23
Graphic Analysis of Optometric Findings
Charles Abel, O.D.
Los Angeles, Calif.
Merrill Allen, O.D., Ph.D.
Bloomington, Ind.
H. W. Hofstetter, O.D., Ph.D.
Bloomington, Ind.
A six-hour course—$12.00
Periods: W-4, W-5, T-4, T-5, F-4, F-5.

The art and science of writing an optometric prescription with the aid of the graphic analysis technique. Selected cases will be plotted and analysed both theoretically and practically to the end of writing a prescription for glasses or orthoptics or both. The problem of prism and/or bifocal prescribing will also be covered.

Course 24
Pharmacology Pertaining to the Eye
Isadore Kaplan, M.D.
Philadelphia, Pa.
Periods: T-E, F-E.
A four-hour course—$8.00

The pharmacodynamic action of certain groups of drugs will be described with particular reference to their availability and usefulness in ocular therapeutics.

Course 25
Dark and Light Adaptation
Alfred Lit, O.D., Ph.D.

New York, N. Y.

A two-hour course—$4.00

Periods: T-8, F-8.

The experimental methods and findings on dark and light adaptation will be presented in detail. Special emphasis will be given to the application of these facts in industrial vision, highway safety, human engineering and the clinical detection of ocular pathology.

Course 26
An Introduction to Slit Lamp Microscopy
Bernard Mazow, O.D.

Houston, Texas

A four-hour course—$16.00

Periods: T-11, T-12, F-11, F-12.

Lectures and demonstrations in the mechanics of using the bio-microscope, methods of observation, etc. The participants will practice using the instrument on each other under supervision of the instructor. If time permits, common pathological conditions will be discussed.

Course 27
Physical and Differential Diagnosis in Optometric Practice
David D. Michaels, O.D.

Chicago, Ill.

A four-hour course—$8.00

Periods: W-11, W-12, T-11, T-12.

Recognition of signs and symptoms. Interpretation of history: how to observe the patient for evidence of ocular and systemic disease (constitution, skin, color, edema, etc.). Confirmation for suspected systemic cause of ocular disease; role of optometrist in recognizing general disease apart from the eye.

Course 28
Strabismus Testing and Diagnosis
T. R. Murroughs, O.D.

Evanston, Ill.

A four-hour course—$8.00

Periods: W-11, W-12, T-11, T-12.

A consideration of basic specific tests to evaluate the type of strabismus in terms of the patient's responses. Differential diagnosis established on basis of responses.

Course 29
Distortion of Stereoscopic Spatial Localization
J. F. Neumueller, O.D.

Haddonfield, N. J.

A two-hour course—$4.00

Period: W-E.

Perception of space is distorted by unequal ocular and/or optical, retinal images. Brief survey of magnification properties of ophthalmic lenses—distortion effects demonstrated by means of stereoscopic cards (qualitatively) and simplified computation (quantitatively). Full discussion of 4 main types: Magnification horizontally - vertically - obliquely - asymmetrically (prisms). Application to every day practice stereoscopic cards. Models-lantern slides-synopsis available for each lecture.

Course 30
Introduction to Aniseikonia
J. F. Neumueller, O.D.

Haddonfield, N. J.

A two-hour course—$4.00

Period: F-E.

Historical background-definitions-symptoms. Presentation of the standard eikonometer (targets, test means, adjustments, procedure, sensitivity, limitations) and the space eikonometer (targets, test means, procedure, sensitivity, limitations). Corrective lenses: Over all magnification, meridional magnification, oblique magnification, single vision lenses, bifocals, and bitoric. Translation procedure: F7 translation—fit over lenses—permanent isoikonic lenses. Frequency of occurance, tolerance, and economics in aniseikonia: Lantern slides and synopsis with each lecture.

Course 31
Turville Infinity Balance Test
Henry B. Peters, O.D.

Oakland, California

A two-hour course—$4.00

Periods: T-2, T-3.

Methods and interpretation of monocular refraction under binocular conditions with special emphasis on anisometropia, suppression, lateral and vertical prism, and aniseikonia screening.

Course 32
Aids for the Partially Blind
Wm. W. Policoff, O.D.

Wilkes-Barre, Pa.

A two-hour course—$4.00

Periods: F-1, F-2.

Classification, description and use of subnormal vision aids:

Distance telescopes, near telescopes, contact lenses, magnifiers and microscopes for near, pin hole spectacles, grid spectacles, hemianopsia spectacles, ptosis and entropion retractors, megascope, recumbent spectacles, the Franklin Institute reader and others. The lectures will be fully illustrated.

Course 33
Pitfalls in Industrial Vision and Design of Occupational Eyewear
Herman Sager, O.D.

Lake Success, N. Y.

A four-hour course—$8.00

Periods: W-E, T-E.

There are many pitfalls that can be encountered in industrial and occupational vision. These will be reviewed as well as practical ways to circumvent these problems. The course also will include the design and application of the various types of eyewear used in industry for protection of eyes and conservation of vision.

Course 34
Visual Acuity Charts
Carl F. Shepard, O.D.

Chicago, Ill.

A one-hour course—$2.00

Period: W-1.

This will not be a specific discussion of charts but a course in the basic principles which determine the limitations of any test of the ability to see.

Course 35
Scleral and Corneal Tonometry
Harold Simmerman, O.D.

Wenonah, N. J.

Ralph E. Wick, O.D.

Rapid City, South Dakota

A four-hour course—$8.00

Periods: W-1, T-1.

This course is designed to acquaint the practitioner with the two principal methods of measuring intraocular pressure. Each member of the class will have the opportunity of obtaining experience with both methods.

Course 36
Glaucoma
Monroe J. Hirsch, O.D., Ph.D.

Ojai, Calif.

Harold Simmerman, O.D.

Wenonah, N. J.

A two-hour course—$4.00

Periods: T-E, F-E.

The incidence of glaucoma especially in the aged makes it necessary that every optometrist fully understand this complicated visual disorder. To meet this need a specific course on the disorder was organized. It includes the etiology, diagnosis, prognosis and treatment. Special consideration is given to the optometric approach of this disease.

Course 37
Management of the Cataract Patient
Frederick W. Sinn, O.D.

Philadelphia, Pa.

A two-hour course—$4.00

Periods: F-11, F-12.

It is commonly known that many difficulties are encountered in meeting the visual needs of patients with aphakia. These will be reviewed; the roles of vertex distance, tilt of the lenses, center thickness, base curves, etc., also will be discussed.

Course 38
The Fitting of the Microlens
Newton K. Wesley, O.D.

Chicago, Ill.

A two-hour course—$4.00

Periods: W-11, W-12.

An advanced course; it will include the history and development of microlenses, basic principles of the lenses, uses, limitations, patient interview, objective factors, subjective factors, and psychological factors. Demonstration of actual patients also will be provided.

Course 39
Geriatrics and Optometry
Ralph E. Wick, O.D.

Rapid City, S. D.

A two-hour course—$4.00

Periods: W-9, W-10.

Geriatrics is defined as the care of the aging and the aged. A brief introduction will be given to the field of geriatrics together with a review of visual changes associated with age. An attempt will then be made to apply the principles of geriatrics to the practice of optometry.

Course 40
Fixation Disparity as a Diagnostic Method
Daniel Woolf, O.D., Ph.D.

New York, N. Y.

A two-hour course—$4.00

Periods: T-8, F-8.

A basic course in the clinical measurement of fixation disparity at near in a refractor; the basis and technique of the test, and interpretation of results with patient discomfort in mind. Actual demonstrations for each participant will be provided.

A Condensed Schedule of all Courses will be found on the following page, and an Order Form for use in enrolling in the Courses will be found on page 447.

A schedule of the Courses by Periods and a Time Chart for your use in selection of Courses will be found on page 448.

The Following Are Condensed Schedules of Courses Previously Described

Course	Instructor	Subject	Periods
1	Abrams	Legal Aspects of Optometry	W-9 W-10
2	Allen	Raubitscheck Arrow Test for Astigmatism	T-9
3	Bailey	Amblyopia, Suppression and Related Phenomena	T-10 F-10
4	Bannon	Problems of Anisometropia	W-1
5	Bannon	Presbyopic Additions - Physiological Basis	T-1
6	Bannon	Oblique Astigmatism	F-1
7	Bechtold	Design of Eikonic Lenses	T-9 T-10 F-9 F-10
8	Bing	Visual Screening of School Children	F-11 F-12
9	Bridgman	Visual Efficiency and Industrial Performance	W-2 W-3
10	Copeland	Streak Retinoscopy	W-4 W-5 T-4 T-5
11	Dowaliby	Design in Eyewear	T-2 F-2
12	Neill Feinbloom Policoff	The Design and Fitting of Contact Lenses	W-9 W-10 W-2 W-3 T-9 T-10 T-2 T-3 F-9 F-10 F-2 F-3
13	Feinbloom	Visual Rehabilitation of the Partially Blind	F-4 F-5
14	Rossett Finkelstein	Optics of Contact Lenses	T-4 T-5 F-4 F-5
15	Fry	Physiological Basis of Discomfort from Glare	[illegible] F-9
16	Fry	Analysis of Problems with Retinoscopy	F-3
17	Graham	Non-glass Ophthalmic Lenses	T-1
18	Graham	Contact Lenses Currently in Use	F-1
19	Grupposo	The Stereoscope as an Orthoptic Instrument	W-E
20	Guth	Recommended Lighting Levels and Their Measurements	W-4 W-5
21	Heath	Office Diagnosis of Color Defects	T-8 F-8
22	Hirsch	The Elements of Statistical Reasoning	W-2 W-3 T-3 F-3
23	Abel Allen Hofstetter	Graphic Analysis of Optometric Findings	W-4 W-5 T-4 T-5 F-4 F-5
24	Kaplan	Pharmacology Pertaining to the Eye	T-E F-E
25	Lit	Dark and Light Adaptation	T-8 F-8
26	Mazow	An Introduction to Slit Lamp Microscopy	T-11 T-12 F-11 F-12
27	Michaels	Physical and Differential Diagnosis in Optometry Practice	W-11 W-12 T-11 T-12
28	Murroughs	Strabismus Testing and Diagnosis	W-11 W-12 T-11 T-12
29	Neumueller	Distortion of Stereoscopic Spatial Localization	W-E
30	Neumueller	Introduction to Aniseikonia	F-E
31	Peters	Turville Infinity Balance Test	T-2 T-3
32	Policoff	Aids for the Partially Blind	F-1 F-2
33	Sager	Pitfalls in Industrial Vision and Design of Occupational Eyewear	W-E T-E
34	Shepard	Visual Acuity Charts	W-1
35	Simmerman Wick	Scleral and Corneal Tonometry	W-1 T-1
36	Hirsch Simmerman	Glaucoma	T-E F-E
37	Sinn	Management of the Cataract Patient	F-11 F-12
38	Wesley	The Fitting of the Microlens	W-11 W-12
39	Wick	Geriatrics and Optometry	W-9 W-10
40	Woolf	Fixation Disparity as a Diagnostic Method	T-8 F-8

AMERICAN ACADEMY OF OPTOMETRY
Post-Graduate Courses

Applications should be made to Dr. D. G. Hummel, 418 The National City Bank Building, Cleveland 14, Ohio. One-half of the total fee must accompany the application. The balance must be paid at the commencement of the courses. Without exception, everyone enrolled in the courses must register and pick up appropriate tickets for each course. Without them, no one can be admitted. Acceptance of applications will be on a first come first served basis. Academy Fellows will receive preference only until October 15, 1955. When the number allowable in any course is filled, applications will be received on a contingent basis and used in case of cancellation. In case of cancellation the fee will be returned, providing such cancellation is received no later than November 19, 1955.

Advance Order Sheet

Please check the courses you wish to take.

CUT HERE AND MAIL

No. of Course	Instructor	Hours	Total Fee	Date	Time

Name _____

Address _____

City _____ State _____

Member of A.A.O. _____ A.O.A. _____ C.A.O. _____ Other _____

For Use of the Committee on Administration

Deposit _____ Balance _____

Date Received _____

Notified _____ Date _____ Accepted _____ Contingent _____

Available Courses by Periods

Time	Wednesday			Thursday			Friday		
8:00 A.M.				21	25	40	21	25	40
9:00	12	1	39	12	2	7	12	15	7
10:00	12	1	39	12	3	7	12	3	7
11:00	28	27	38	28	27	26	37	8	26
12:00	28	27	38	28	27	26	37	8	26
1:00 P.M.	34	35	4	35	5	17	6	18	32
2:00	12	9	22	12	11	31	12	11	32
3:00	12	9	22	12	22	31	12	16	22
4:00	10	23	20	14	10	23	23	13	14
5:00	10	23	20	14	10	23	23	13	14
7:30	19	29	33	24	33	36	24	30	36

Form for Selection of Courses

Hour	Wed.	Thurs.	Fri.
8			
9			
10			
11			
12			
1			
2			
3			
4			
5			
E			

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There's an air of elegance about the Art-Rim Leading Lady that accounts for its wide popularity as a frame for women. New patterned zyls and rich solid colors offer a wide range in fitting. Available in a variety of beautiful trims. Model shown with Royal Baguette trim.

Colors: Briartone, Demi-Blonde, Bronze, Blue Mesh, Coca Mesh, Black Marble, Black & White, Black & Pink, Blue Slate & White.

7□ DIFF.

Eye	A	B	E BRIDGE
40	41.5	34.5	18-20-22
42	43.5	36.5	18-20-22-24
44	45.5	38.5	18-20-22-24
46	47.5	40.5	18-20-22-24

P.D.—A+E 43.5+20—63.5 P.D.

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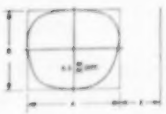
The "go-with everything" rightness of the Art-Rim Townsman is an important factor in its universal appeal. its distinctive, clean-cut, casual styling blends with all the clothes and pursuits of daily living. Rarely does a single frame offer such complete satisfaction . . . for patient . . . for you!

Colors: Briartone, Grey Slate, Gunner Brown.



EYE	A	B	E BRIDGE
42	43	38.5	20-22-24
44	45	38.5	20-22-24
46	47	40.5	20-22-24
48	49	42.5	20-22-24

P.D. — A+E 43+20 — 63 P.D.
Available in Briartone, Demi-Blonde, Gunner Brown and Grey Slate.

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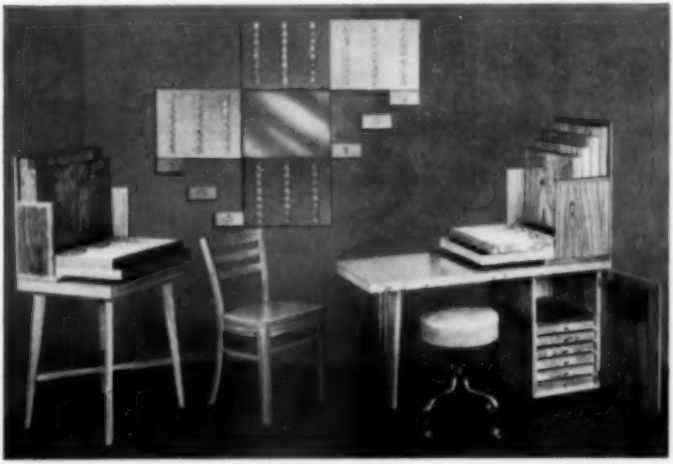

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